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In Two Sections — Section I

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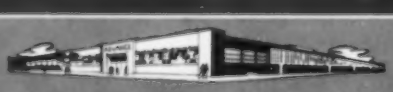

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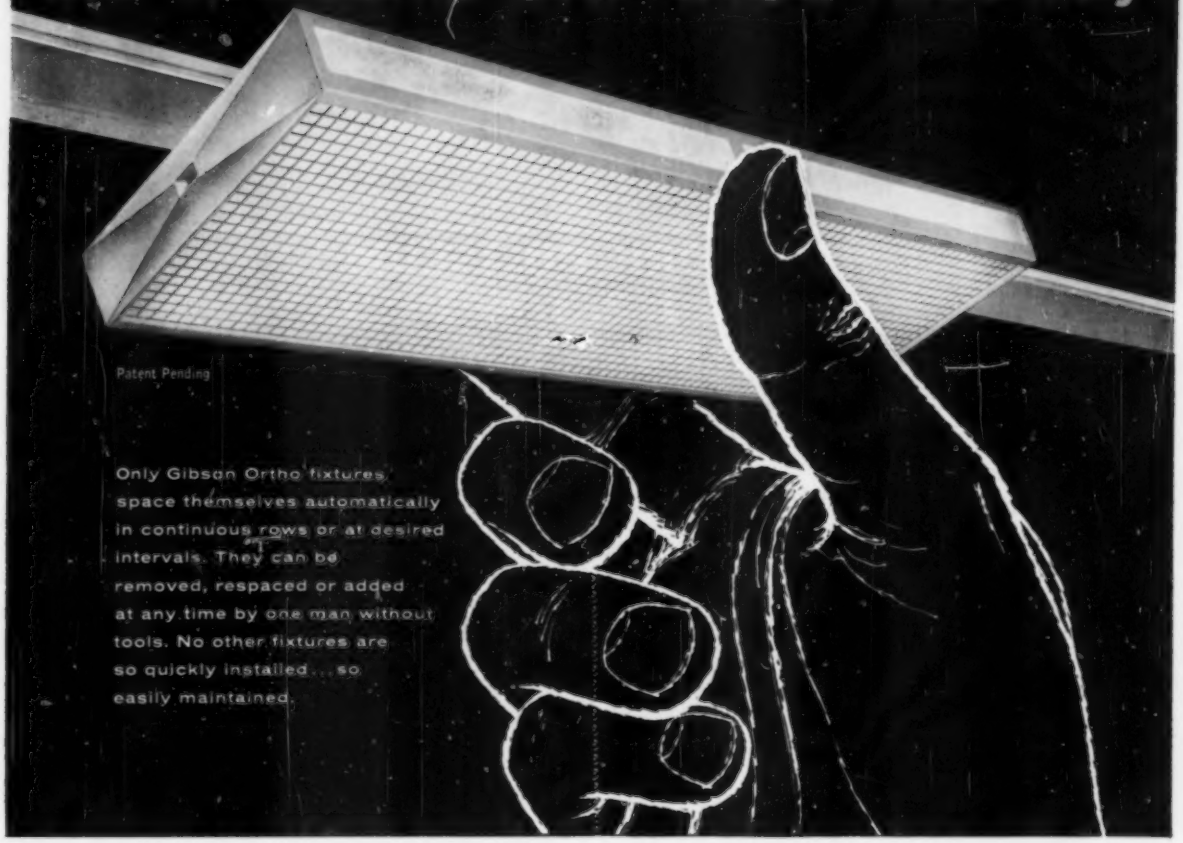

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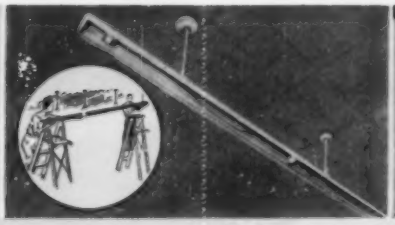

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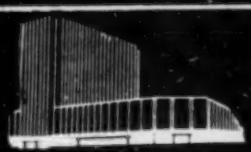

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3) 1-2 P.M.—Street & Highway Lighting
4) 2-3 P.M.—Light & Architecture

TUESDAY, MAR. 3, 1959
5) 10-11 A.M. Institutional Lighting (Banks, Public Bldgs., Schools, Hospitals)
6) 11-12 noon — Lighting for Selling (Dept. Stores, Super Mkts., etc.)
7) 12:45-1:30 P.M. — Polarization — its Relation to Lighting
8) 1:30-3:30 P.M.—The Blackwell Report

WEDNESDAY, MAR. 4, 1959
9) 10-11 A.M.—Residential Lighting
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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

January 1959

Vol. LIV, No. 1
In Two Sections
Section 1

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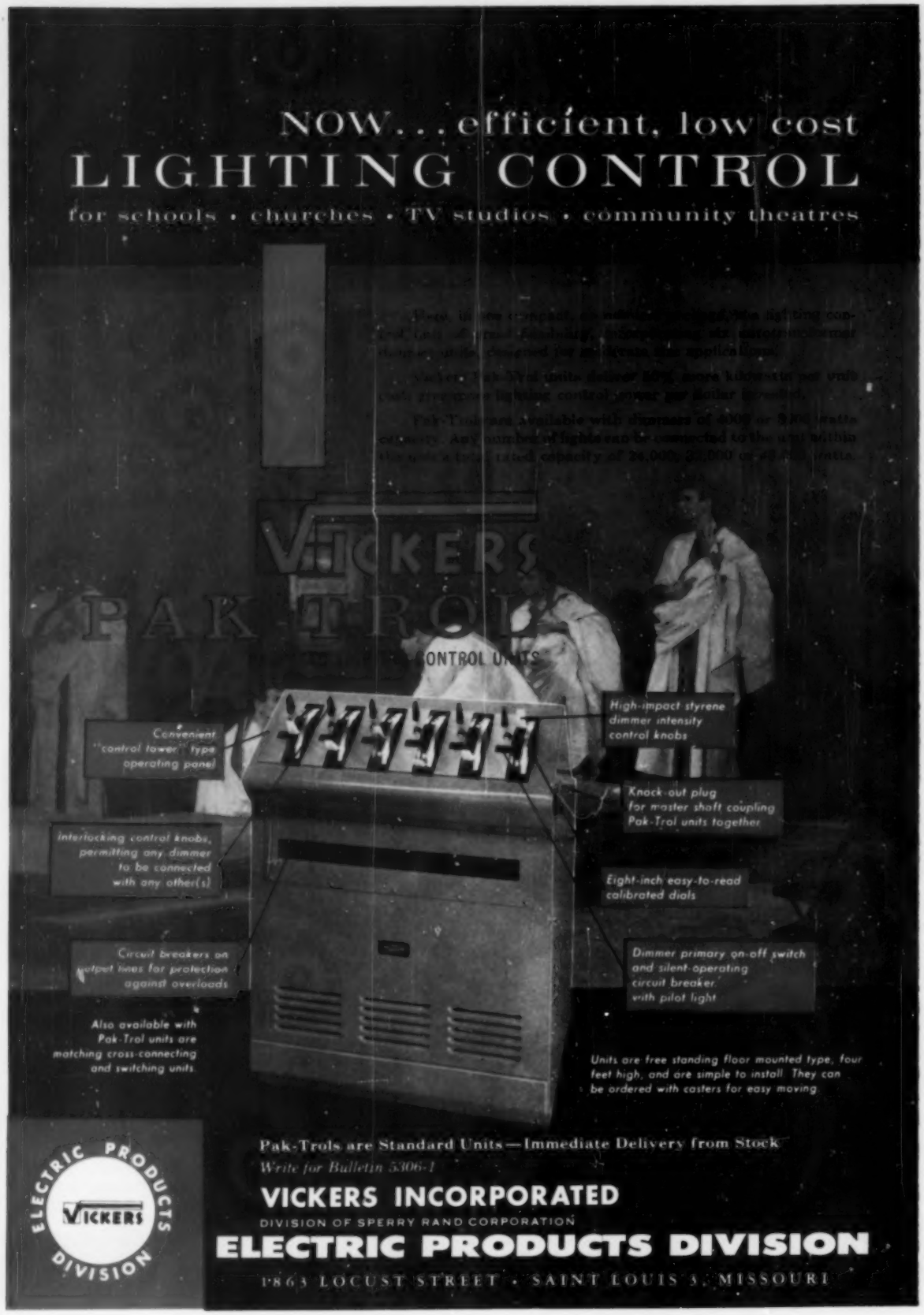
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Today we are ten . . .

Actually, the Society and its journal are 53 years old. But ten years ago this issue, Illuminating Engineering took such a completely new direction that its birthdays have been numbered from that day, to this.

Nothing is static and one has to start somewhere, but a ten-year anniversary is a nice plateau to pause for a look around. The conclusion after such a look? It's been quite a decade!

Who would have thought, in 1949, that there would be a Republican in the White House, jet passenger planes flying from New York to California (and Europe), a baseball team called the Los Angeles Dodgers, earth satellites, a forty-ninth State? Nobody predicted scientifically-backed recommendations of footcandles in the hundreds, either, and certainly not in the thousands.

Regular ten-year growth is, of course, easy to see. In the "new IE's" life span, for example, the Society has grown from 6711 members to 8183 (almost a 22 per cent increase); from 42 Sections and Chapters to 84 (100 per cent).

IE itself has grown from a press run of 7900 for its first issue to 13,400 for this one. And it averages about 120 pages per issue now, against 70 to 80 ten years ago. Best of all, though, is its ten-year growth in influence and leadership, also nicely measurable. Some 1800 copies of every issue, for example, go to non-member architects, sent to them by the utilities serving them. This service was initiated by one utility following its year-long study of IE for its value to architects. Its influence is further extended through the literally thousands of reprints which are in demand for its published material.

The industry itself has had quite a decade, and the profession also. One of the most significant advances for lighting these ten years past has been the growing extent of its acceptance as an element of design. The combination of function and decoration for lighting design was only an "understanding" between the couple ten years ago. Now it is a successful marriage. A by-product of this appreciation of lighting as an art is the ascendance of the lighting consultant — a profession which has itself grown almost beyond belief, in this ten-year period. It is no accident that this decade's most notable structures are as much admired for their lighting design as for their architectural beauty. In fact, one architectural magazine in its September 1958 issue devoted its entire book to the happy marriage of lighting and design — having as its theme the tenet that "Lighting *is* Architecture."

Advances in equipments, light sources and industry developments during this period are in great measure responsible for these remarkable "trends" in lighting. A review of the Society's past ten Progress Reports is a revealing glimpse of the changes in methods for the control of light, in the tools of the profession and in techniques for applying them.

IE's tenth birthday, it so happens, occurs just at the beginning of additional very big things for lighting practice. Researches just completed this past year will make the next decade even more interesting to watch.

Ruby Leckford

Editor

Dome under construction. Thirty-foot hexagonal steel panels were welded together, supported externally by hexagonal array of compression pipe elements and tension rods.

Geodesic Dome
FACTS and FIGURES

SIZE AND LOCATION:

Situated on a 36-acre plot of land in Baton Rouge, Louisiana. Largest geodesic dome in world — large enough to contain a football field or major league baseball diamond. 384 feet in diameter, 120 feet high at zenith, covering interior ground area of 110,000 square feet. First major industrial application of geodesic design principle.

FACILITIES:

Interior Dome — A second geodesic structure, a building within a building, 80 feet high, 100 feet in diameter, encompassing 7500 square feet of floor space. Located 25 feet off-center of large dome, at hub of repair operations. Contains materials storage area on ground floor; administrative offices, reception room, employees' dining room, locker and shower facilities on main floor. Concrete observation deck above main floor provides space for construction of additional offices, if needed.

Control Tower — Located at top of interior dome. Is glass enclosed, permitting work-coordinator to view and direct all repair operations. Closed-circuit TV enables work-coordinator to watch inspection of cars as they enter dome and know what repairs are needed.

Repair Track — 2160 feet (almost half a mile) in a wheel-like arrangement around edge of large dome. Has 36 specialized repair positions, including 3 incoming and 3 outgoing tracks.

Whiting Transfer Table — Carries one car at a time to various repair track stations. Moves on a circular course 50 feet wide between storage area in interior dome and repair areas on circumference of dome.

Paint Tunnel — Connected to main dome. 200 feet long, 40 feet wide, 20 feet tall. Covers one of the outgoing tracks and is last stop in repair operation. Workers here are equipped with scaffold elevators which move up, down and sideways, eliminating necessity for climbing up and around cars.

CONSTRUCTION DETAILS:

321 hexagonal 11-gage steel panels, ⅛-inch thick, welded together and strengthened on outside by interlocking system of rods and pipes. 12 different shapes and sizes of panels, majority approximately 30 feet across. Panels fabricated on location and erected without scaffolding.

DECORATION:

Outside painted bright yellow to reflect heat and accentuate tendency of panels to be in tension. Outer framework, royal blue, to absorb heat and increase compression tendency of framework. Interior, pale peach. Machinery, various bright colors for safety and ease of identification. Interior structure, off-white with royal blue trim. Paint tunnel, yellow, to match exterior of large dome.

COST:

Large dome, well under $10 per square foot of floor space covered. Total cost of dome less than $1,000,000. Entire project, including repair and maintenance facilities, slightly more than $3,000,000.

DESIGNED BY:

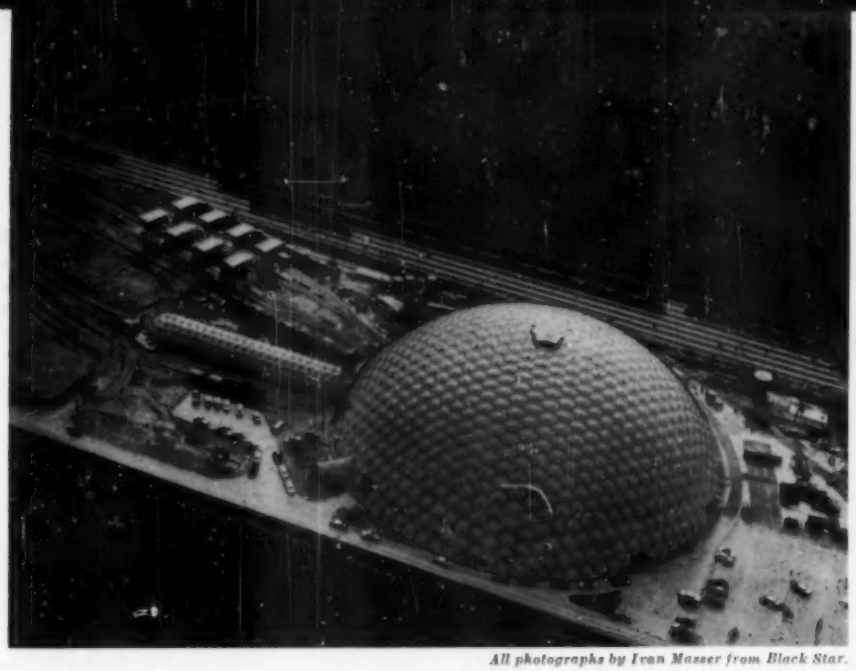
Union Tank Car Company, Department of New Plant Development and Operations, headed by R. A. Lehr, Project Engineer, in cooperation with R. Buckminster Fuller of Synergetics, Inc., Raleigh, North Carolina, developer of geodesic dome principle.

DECORATION AND LANDSCAPING BY:

George S. Hunt, Industrial Designer, New York, New York.

LIGHTING BY:

Abe Feder, Lighting by Feder, New York, New York.



All photographs by Ivan Massar from Black Star.

Geodesic Dome and its lighting

1958 Achievements

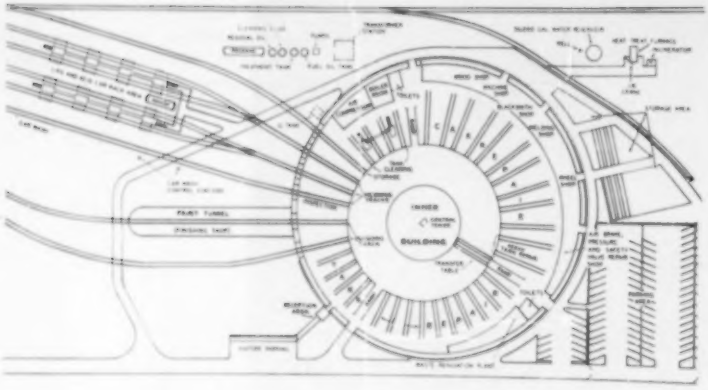
BUILDING design developments, plus architectural advances, added to changing materials, equal new lighting techniques. And sometimes vice versa? The past decade has seen all-glass buildings, no-glass buildings, previously unheard-of building materials, methods, and designs. Developing right along with these architectural advances have been lighting systems and sources which have enhanced and/or made practicable the extraordinary developments in building design.

The year's most remarkable structure was probably Union Tank Car Company's repair and maintenance facility at Baton Rouge, Louisiana. This giant dome (see Facts and Figures) is the largest application of the geodesic principle, the basic formula for which was developed by R. Buckminster Fuller, and its first industrial use. Smaller geodesic structures have been used for the domes created along the DEW line as part of the arctic radar warning system. Should this design prove a forerunner for industrial buildings, then Abe Feder's lighting for it has very topical interest.

This enormous dome consists of 321 hexagonal steel panels of only one-eighth inch thickness, welded together and strengthened by an external spider web frame of rods and pipes. There are no interior supports; the dome encompasses 110,000 square feet of unimpeded floor area. Although the basic geodesic design was probably not possible until the advent of computers, actually its construction is simple, and in terms of its size and purpose, remarkably economical. Cost for the structure is stated to be well under $10 per square foot for floor area covered, or less than $1,000,000.

The dome is approximately a one quarter sphere, designed and constructed of steel as a three dimensional curved truss. The truss, approximately four feet deep, is designed as a unit cell system of octehedra in which the involuted 11-gage sheet metal surface material is employed both as the weathering surface and as the inner member system of the truss. The outer hexagonal array is composed of four-inch steel pipe sections approximately nine feet long positioned with three-quarter-inch tension rods. The compression pipe elements and the tension rods lie along the typical geodesic great circle grid lines. The steel sheet fold lines repeat the geometry of the pipe and rod system. The basic raw material of 11-gage sheet steel, one-eighth-inch thick, was first cut into triangular pieces, welded into diamonds and then into the hexagonal panels. There are 12 slightly different shapes and sizes of panels. The majority are about 30 feet across.

The dome was erected entirely without scaffold-



Radial track plan for maintenance and repair stations for the railway tank cars. Via central turntable, the cars are moved to the men and materials as required, rather than the more costly reverse procedure previously the practice. Painting and finishing are done in the paint tunnel at left.

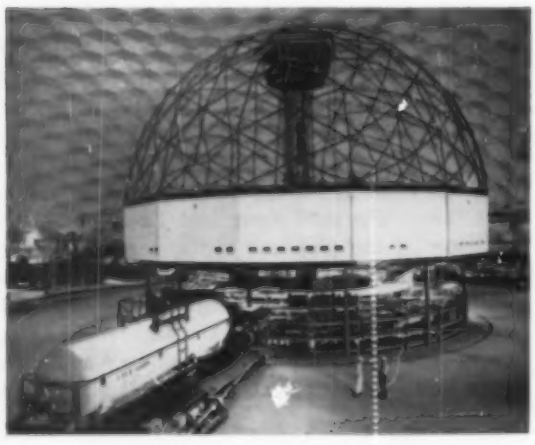
ing, a 40- to 50-man construction crew using up to six cranes for hoisting the panels into place. Work was begun at the base and continued concentrically up to the zenith. Positioning poles were used as aids in making panel adjustments as the sub-assembly panels were brought into edge contact. Drift pins were used as panel corners for first alignment and the sheets were then seam welded.

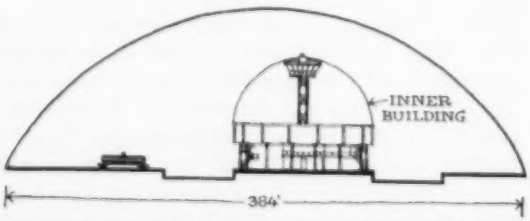
How Was It Lighted?

Obviously with a totally enclosed dome, lighting was the all-important factor which would make its use as a work area possible at all. Lighting consultant Abe Feder and industrial designer George S. Hunt (both of New York) had, however, much more in mind than sufficient footcandles for the work task. This too, of course, but a major goal for the lighting was avoidance of a "heavy industry" atmosphere, and achievement of "human-ness" and "visual experience," even in so huge an area, as well as functional levels for industry. There were, of course, no supports on which to mount lighting equipments, and physical characteristics of the area were, at least, unorthodox for lighting design.

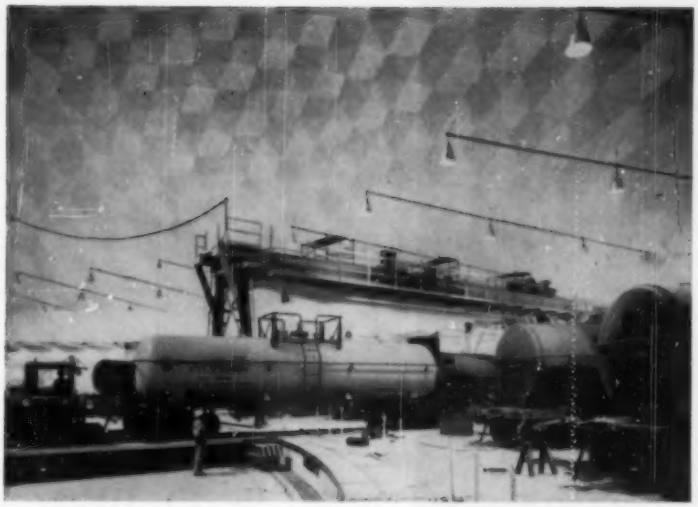
The lighting system developed by Feder might be described as combining the known principles of interreflection, color, and light control, all abetted by a specially designed high-lumen-per-watt light source—a 1000-watt improved-color mercury vapor reflector lamp. Whether this is of a radically new design and/or projects the most powerful beam of any light source of equal wattage has not yet been documented. Either way, however, it very successfully achieves the quantity and quality sought for the system. The new lamp is used with a new type of reflector, also specially designed, which further intensifies its beam and which enhances its color rendition by a peach-color reflecting surface.

Some 106 of these new luminaires are located 34 feet above the radial work area, arranged in three tiers of concentric circles, from a "wheel" around the entire periphery. Illumination level is from 70 to 90 footcandles at the work task. Beneath the control tower, which is mounted on a dome within the dome housing offices, cafeteria, lounges, etc., 60 additional luminaires with peach-colored filters are focused on the dome above. Interreflections, from the multiple facets of each of the hundreds of





Location of the interior structure "office building" is 25 feet off-center of the dome, but at the hub of the giant wheel-like arrangement of tracks and repair stations. The circular interior building is 80 feet (seven stories) high and 100 feet in diameter. Its ground floor is the materials storage area. The enclosed main floor, 18 feet above ground level, provides space for executive offices and employee quarters. Control tower, nerve center of the repair operation, is at the top.



Tank car in process of movement off the transfer table to repair position, bringing cars to men and material. Illumination level at working areas is 70-90 footcandles.

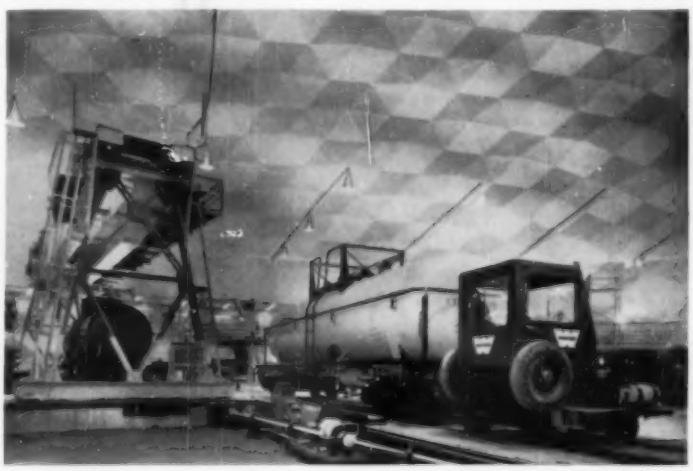
panels of which the dome is constructed, result in a remarkable lighting environment. The surface of the dome's interior appears off-white. Actually it has been painted peach color also. The resulting effect, in this vast area, is one of "mellow indirect radiance."

As to maintenance, it is expected that dirt collection on so high a surface will be negligible. Pending time-use experience, plans are for repainting in perhaps five years.

One half of the dome is floodlighted at night, using a variation of the new lamp and reflector, targeted 350 feet away. Exterior of the dome panels has been painted a high reflectance yellow, with the pipe-and-rod truss work a bright blue. Here again, interreflections from the geometric positions of the panels' facets, and the system of non-uniform floodlighting, result in a sculptured appearance. The effect is of a huge golden dome — an impressive sight.

Another feature of the property is a glass-enclosed control tower; this is at the top of a center structure within the dome which serves as an "office building." There is also a paint tunnel 200 feet long, 40 feet wide and 20 feet high, which extends outward from the main dome area, covering one of three exit tracks for tank cars. This too has been constructed with Fuller's geometrical panels.

Enthusiasts of this geodesic design predict versions of the structures eventually enclosing entire shopping centers, sports arenas and athletic fields, school and civic auditoriums, and office buildings as well as factories. Such predictions may not be just dreams. When the Los Angeles (nee Brooklyn) Dodgers were still pondering means of remaining in Flatbush, President Walter O'Malley had a design made and a model built of a geodesic-domed stadium. Although this first tentative plan for a dome-covered baseball field came to naught, the hope of an end to rain checks lingers still.



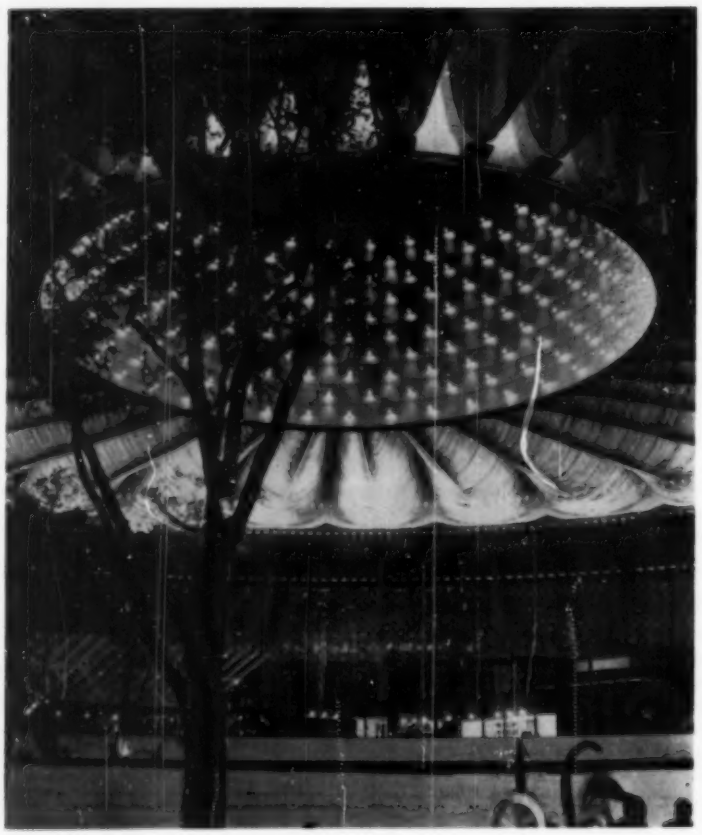
Specially designed high-output mercury vapor lamps with special reflectors and peach-colored filters achieve the lighting goal of visual comfort and functional levels for industry. In addition to the units seen here, luminaires mounted on the central structure, targeted upward, provide general lighting and interreflections from the many-faceted dome.

1958 Achievements

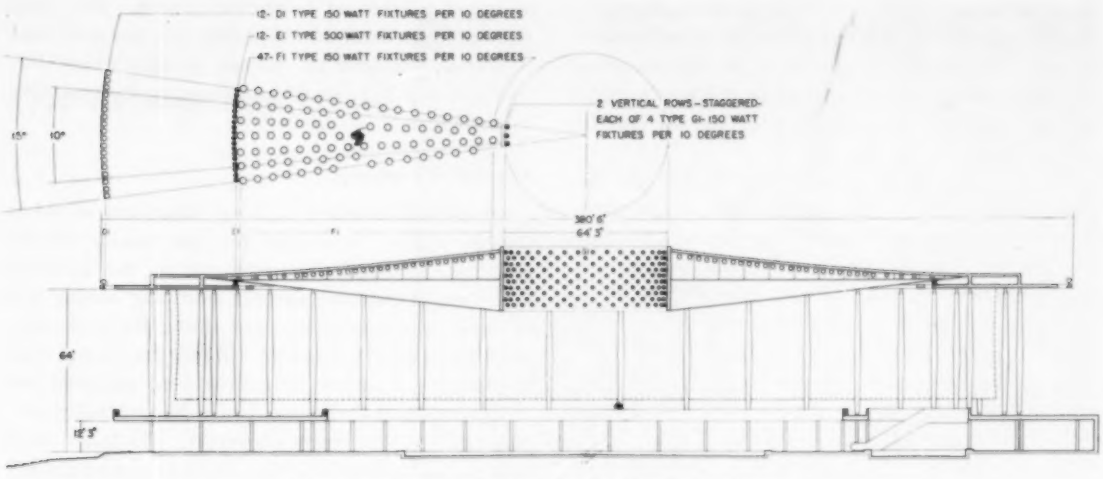
BRUSSELS WORLD'S FAIR

lighting for the

Photographs courtesy of International Lighting Review, *Amsterdam, Netherlands.*



Draped metallic mesh ceiling with center drum open to the sky. 150-watt reflector lamps in weatherproof sockets provided powerful downlighting to a pool below, and formed a column of lighted raindrops during rainy weather.


12- D1 TYPE 150 WATT FIXTURES PER 10 DEGREES
12- E1 TYPE 500 WATT FIXTURES PER 10 DEGREES
47- F1 TYPE 150 WATT FIXTURES PER 10 DEGREES
2 VERTICAL ROWS - STAGGERED-
EACH OF 4 TYPE G1- 150 WATT
FIXTURES PER 10 DEGREES
15°
10°
380' 6"
64' 5"
64'
12' 5'

Cross-section of pavilion showing lamp positioning.

United States Pavilion

WHATEVER opinions were bruited about regarding United States exhibits at the 1958 World's Fair, the Pavilion itself received unanimous praise. What its admirers undoubtedly responded to was the liaison of lighting and architectural designs. Major purpose of the lighting, though functional as well, was to further beautify the building, and to achieve the effect sought by the architect. If large expositions are milestones in lighting progress, and they have been many times in the past, then the 1958 World's Fair might be said to exhibit lighting as an art, as envisioned by the architect, and as both a science and an art, as executed by the lighting consultant.

In shape, the United States Pavilion was cylindrical, with a diameter of 380 feet 6 inches, and a height of about 64 feet. The building was constructed so that the walls were of transparent plastic and the roof was covered with translucent plastic, to which, of course, its lighting design gave a wondrous effect at night. The roof was in the shape of a bicycle wheel in which an annular concrete ring corresponded to the bicycle rim and a number of steel cables, to the spokes. The entire roof structure was thus suspended from the outer ring, which rested upon two rows of steel columns.

The entire ceiling was draped with meshed metal in great folds, constructed of metal discs. The outer wall of the Pavilion was also covered with a net of metal mesh with large metal knobs. This large grill had a structural purpose as well as being a decorative distinguishing feature of the building's appearance.

The suspended metal mesh ceiling and the lighting system for it together formed a decorative effect of great beauty. The mesh comprised over 10,000 square yards made up of 2½-inch diameter convex gold-finished metal discs flexibly linked at the rate of 16 discs per square foot. In daytime, light through the plastic roof was shielded by the mesh of the draped ceiling material, and at the same time was seen in interesting brightness patterns through its network of small openings. To obtain an effect of sparkle, and to maintain at night the general effect of light coming through the mesh from above, 1692 reflector lamps were suspended above the draped folds. The flood lamps, each 150-watt size, were positioned in a specific pattern to produce myriads of twinkling reflections through the thousands of gold-colored metal links. These lamps were controlled in concentric circular rings by dimmers so that the lighting level could

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Lighting consultant for the United States Pavilion was ***Rollo Gillespie Williams,*** *Century Lighting Inc., New York City, working with architect* ***Edward D. Stone,*** *also of New York.*

be adjusted to provide a variable pattern of brightness values from center to edge of the circular mesh ceiling area. Another function of the dimmers was to permit the lamps to be used on a lower voltage so that their life was extended for the six months period of the exhibition.

The draped mesh ceiling was lighted on the underneath side by 500-watt PAR64 lamps, positioned above the inner rim of the concrete annular compression ring which rested upon the circular wall structure. A total of 432 lamps of 500-watt size were employed. These were positioned not only to be concealed, but also to illuminate the 432 oblong translucent panels which were spaced near the edge. The lamps had a narrow spot distribution with an initial candlepower of 110,000, and a beam spread of 13 degrees by 20 degrees. Insofar as all the lamps were directed toward the outer surface of a center drum, the light was channeled between the main ceiling folds of the metallic mesh. This provided sufficient light to illuminate the under fold of the mesh for the throw distance of approximately 100 feet.

Suspended Center Ceiling Drum

One of the building's most unusual effects teamed structure, light and even the elements, for its beauty. This was a circular drum, open to the sky, and "lined with light," at the center of the building. Rain or shine, the effect was most impressive, and if anything, even more beautiful on a rainy night. Rain descending through the opening was caught in a pool beneath it in the pavilion; the illuminated "curtain" of rain drops provided additional sparkle to the scene.

The drum, 60 feet in diameter and approximately 23 feet in depth, was "lined" with 360 reflector lamps, 150-watt, in weatherproof downlights. These were arranged on the inner cylindrical drum surface in ten horizontal rows with lamp positions in alternate rows, staggered as shown in the illustration. The downlights were mounted with a vertical axis parallel to the vertical side of the drum, providing a pattern of brightness points. They also provided powerful downlighting into the pool, and of course, provided the column of light which illuminated any rain coming in through the open top of the drum.

Outside Overhang

Another interesting lighting effect was achieved by the system developed for the outside of the pavilion. Around the outer rim of the building there was a concrete circular overhang having 432 specially shaped oblong open slots. Each of these slots contained a 150-watt PAR38 floodlamp with weatherproof socket. The slots were designed not only to conceal the lamps, but to be internally illuminated by them (see photograph). The lamps were positioned in these 432 slots so as to illuminate the circular "net" grill work on the outer wall from top to bottom. Light was also projected into the inside of the pavilion through the translucent wall material. This lighting arrangement also provided a pleasing general illumination around the upper area of the pavilion.

Exterior Grounds

The site of the United States Pavilion, an area of about 6½ acres, contained 120 apple trees — in full bloom when the Fair opened in April. During apple-blossom time and later, the grounds of the American Pavilion were a compelling focus of attention, and especially at night. Each of the 120 apple trees was effectively lighted from concealed units sunk into the ground and arranged to throw light upwards into the branches. Four 75-watt reflector lamps were used for each tree.

A pool on the grounds was provided with underwater lights for each of its 42 gyrating fountains and also for the sculptured figures surrounding it.

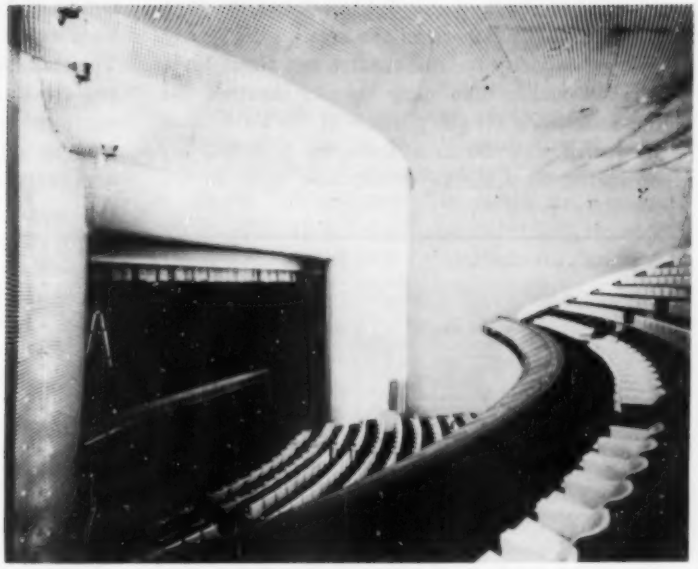
As seen from within or without, on rainy days or fair, and in daytime or at night, the United States Pavilion was an outstanding attraction at a Fair which was universally praised for its unusual and beautiful buildings.

Index to 1958— Officer-Committee Directory

The annual Index to 1958 ILLUMINATING ENGINEERING, published as Part II of this issue, gives the business addresses, where available, of IES officers and committee personnel for 1957-1958 and 1958-1959, and so can be used as a directory for these active IES members.

1958 Achievements

BRUSSELS
WORLD'S
FAIR



United States Theatre

Such extensive publicity was given to America's Pavilion at the Brussels World's Fair that few people realized a theatre was also part of the United States exhibit, that is, few people who were not there. For visitors to the Fair, the theatre was a première attraction.

Though quite a separate building, the theatre was an adjunct of the pavilion. Its main entrance was through the pavilion; even its ground plan was round, like the pavilion's, though somewhat smaller. Its walls repeated the famous grid motif which so distinguished the main building.

Lighting for this building presented many interesting problems, particularly that for the interior of the auditorium. This was entirely lined, walls and ceiling, with a mesh made of gold discs on gold straps. The architect for the United States buildings had successfully experimented with this technique in his design for the Music Auditorium at the University of Arkansas, and had also installed such a system in one of New York City's motion picture theatres a few years ago. The effect is to give a very delicate wall and ceiling treatment which has been much admired.

As with the pavilion itself, lighting for the auditorium was both functional and a predominant part of the decorative plan. About four feet above the mesh ceiling, for example, some 100 R-40 floodlamps of 150-watt size were mounted on stems, providing sufficient downlighting for program reading and general circulation. At the same time, the gold metal mesh was sparkled, from every direction, by 36 decorative units suspended below the ceiling mesh to light the face of the side walls and ceiling discs. Behind the mesh on the side walls, about 300 units using 25-watt silver-bowl lamps were wall-mounted on short stems on three-foot centers. This provided a glow from all sides in a "pin-cushion" effect. The mesh was highlighted additionally, of course, by the directional lighting flooding its surface.

Beneath the balcony, thirty 200-watt wide-angle low brightness units provided additional functional illumination for this area. The promenade, the space at the rear of the seating area, was lighted by flush downlights, similar to those under the bal-

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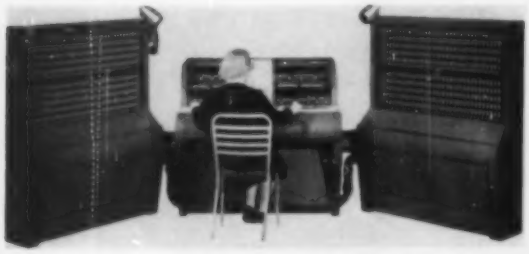
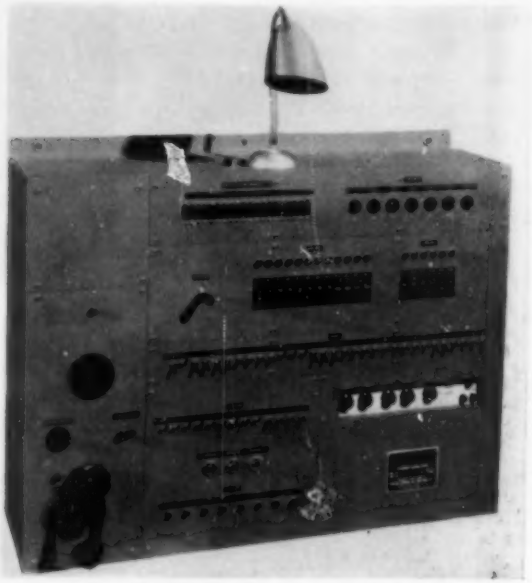
Lighting consultant for the United States Theatre was ***Stanley McCandless,*** *Century Lighting Inc., New York City, working with architect* ***Edward D. Stone*** *and stage designer* ***Donald Oenslager.***

cony. Aisle lights and exit lights were of the type familiar to many American theatres.

Seating capacity for this theatre was about 1200, somewhat smaller than many big city theatres, but judged adequate for the purpose of the Fair. Seat distribution was 400 in a European-type balcony (considered by some to be the best seats in the house) and 800 on the gently sloping floor. Sightlines were excellent and the seats very comfortable. The stage was ample for any type of production or performance except grand opera, and was fully equipped with rigging and lighting equipment for staging musicals, dramas, ballets, motion pictures and lectures. Purpose of this part of the American



Console and preset panels, as set up in the booth. Close-up, below, of console shows the two manuals and the master control panels.



Stage manager's panel, showing the control center which is mounted at stage left.

Face of patch panel showing the 300 odd load circuit plugs on the ends of weighted cords in the horizontal plane and the 72 multiple jack pockets connected to the dimmers in the vertical plane.

Portable stage manager's desk that permits him to move to a position where he can easily see the action on the stage and control all the cues and communications concerning various parts of the production.

exhibit was, of course, to show typical examples of American theatrical art.

The eminent stage designer, Donald Oenslager, was called in by architect Edward D. Stone to advise on the auditorium and stage arrangements. The lighting system, an important part of the theatre layout, was designed to represent today's best professional practice and to include a number of things which even the American professional theatre would like but has so far not been able to acquire. The new theatres built in this country recently have been mainly in the universities, consequently the latest innovations are found, for the most part, in amateur playhouses. For some thirty years now, only renovations have been made in most of our professional theatres.

Stage Lighting

Although the average professional American stage does not have permanent equipment, the Brussels' theatre seemed an ideal place to install a full complement of spotlights, floodlights, strip lights, etc., so that visiting companies would not have to supply their own, as they do in the United States. Another feature was the inclusion of a switchboard, likewise used in portable form in America. For this theatre, it was decided to exhibit an electronic type of control recently developed in the United States. The various details of the layout were:

Booth — This was divided into several sections for motion picture projection apparatus, follow spots, sound control and lighting console — the switchboard. The arrangement allowed the operators to see precisely what was happening on stage so they could follow cues and catch errors. It was also much simpler to do the preliminary lighting set-up from this position than from backstage where the operator could not see what was going on.

Balcony Front — A continuous slot was built to house balcony front spotlights, up to thirty in number, if required. This was architecturally integrated into the fascia of the balcony so the spotlights would not disfigure the interior of the auditorium, as is customary in this country.

Ceiling and Wall Slots — Hidden behind a fold in the mesh, across the entire width of the auditorium and running part way down the side walls, was a slot for mounting as many as 40 front spots to light the front of the stage or the orchestra pit.

Proscenium Slots — At either side of the proscenium two slots, which could accommodate eight or ten spots on each side, were hidden behind the mesh. These gave a flat throw toward the platform from the sides and provided entrances to the apron from either side.

Orchestra Pit — This standard forestage pocket accommodated about thirty musicians and had shielded lights on the music stands, as is the practice in the United States. The conductor, however, had an integrated podium, connected with the stage manager's control board for appropriate signals.

Disappearing Footlights — Five sections of footlights, each equipped with 150-watt lamps and controlled in three circuits, were stretched across the front of the stage. Any number of sections could be used. When no footlights were needed, the entire front of the apron could be flat.

Proscenium Arch — This was approximately 36 by 24 feet (average size) and was equipped with both an asbestos and an act curtain. An adjustable masking teaser (draped curtain which frames the top of the opening at any desired height) and tormentors towers (structures on either side of the stage which can be moved on and off to adjust the width of the opening) were included in the scenic equipment. Behind the teaser were two light pipes, one for carrying up to 30 spotlights, the other for four to six portable sections of borderlights. The borderlights were 150-watt R-40 lamps; the spotlights, ellipsoidal reflector and Fresnel types, both with 750-watt lamps. Eight to ten spots, similar to those described above, were located on either side of the tormentors for use in side lighting.

Boomerangs — Slightly upstage from the tormentor towers, in the second entrances, were four vertical pipes, screwed to the floor and extending 20 to 30 feet upward on either side of the proscenium arch. Each pipe carried between eight and twelve spots for side lighting.

Ladders — Hung from grid-iron, somewhat outside the boomerangs, were frames used for carrying spotlights and narrow beam projectors, modelling and accent beams from the high side, in the second, third and fourth portals.

Side Galleries — On either side, about 30 feet above the floor were two galleries from which follow-spots could be directed on stage and from which point the operator could handle any type of projection equipment needed. All overhead lighting equipment was fed through portable cables connected to plug-in strips mounted on the rails.

Supplementary Equipment — For mounting spotlights, backdrop lights, back-lighting units and other special effects over the stage, a pair of light

pipes was installed just behind each of the four portal arches.

Auxiliary Equipment — The stockroom held an extra supply of 1000- and 2000-watt spot and floodlights which could be used from stands or mounted on pipes, wherever needed. A number of effect machines of the 2000- and 3000-watt size (machines more common to the European than to the American theatre) were also on hand, as well as several short three-color striplight sections, mounted on casters, which could be used as cyclorama foots, at the base of backdrops, or for lighting translucent backings.

Outlets — Mounted at various strategic places around the theatre were some 300 duplex 20-ampere twistlock receptacles on pigtails. Each of the 300 circuits was connected to the plugs in the cross-connecting or "patch" panel, located offstage near the stage manager's control board. At this point, the operator could plug in any combination of spotlights by inserting the plugs into the jacks which were fed by the 72 control circuits controlled from the console in the booth. Repatching could be resorted to at any time, and there were also about a dozen hot pockets which permitted testing of equipment without heating up the electronic console.

Stage Manager's Panel — Located at stage left was an elaborate communications center so the stage manager could monitor and transmit directions to all parts of the stage, by telephone, light or sound signal, at any time.

Switchboard — This 300 kw, permanently installed switchboard was composed of four parts, the console, the preset panel, the patch panel and a tube rack. The console, located in the booth so the operator would have a good view of the stage, contained 72 finger operated controls in two manuals and a master panel. The top manual was composed of potentiometers for controlling 36 5 kw tube circuits; the lower manual controlled 36 2½ kw circuits. On the master panel were the preset selector switches for ten scenes and blackout in two rows. The "fader" lever was placed at the end of these rows. Four sub-master manual masters and one manual grand master controlled the circuits switched to manual position. There were also ten no-dim circuits, controlled by switch, for supplying current to table lamps and circuits that did not require dimming. Motor-operated dimmers controlled by levers regulated the house lights.

On each side of the console was a preset panel consisting of ten rows of potentiometers, 36 in each row. These corresponded to the 72 controls on the console, and when the selector switch at the base of each manual control on the console was thrown to the "down" position, these controls took over. In this way it was possible to preset the intensity of any circuit in advance so that an entire scene could be faded or switched through the fader control or selector switch control in the master panel of the console. The fader allowed a proportional dim from the intensity levels of each instrument of one scene to those of another scene without any perceptible dip, if the light level was to be the same in the following scene. This, in a sense, was a memory feature with stored set-ups, permitting a return to previous scenes or an advance to future scenes, if desired. For the first time, a simple proportional fading of all lights of a set-up was made possible.

The patch panel, described briefly above, was associated with the stage manager's panel on stage.

The fourth part of the control system was the tube rack, located in the theatre basement and composed of 72 chassis, each with a pair of Thyratron tubes mounted back to back, which were controlled from the console by phase shifting through the potentiometers. The fader mechanism was partly in this tube rack and partly in the console. Booster transformers and house dimmers were also in the tube rack.

Other Lighting

A combination of concealed units and decorative fixtures provided the lighting in the rest of the theatre; pinhole downlights in the lounges and standard low brightness fluorescent luminaires in the offices. One item of special interest, however, was the perimeter lighting behind the exterior grille. The theatre, like many of Mr. Stone's buildings, was surrounded by a grille which permitted daylight to filter in through the exterior glass walls. For nighttime lighting, this served as a pocket for 500 150-watt PAR spots equipped with 55-degree roundels. This treatment created a lacy effect on the grille and gave a daylight glow to the interior of the theatre when the curtains were drawn over the windows at night.

The budget for this theatre was said to have been about $3,000,000 and the program presented in it was studded with a great variety of special productions, designed to show the great variety of extent of theatre art in the United States today.

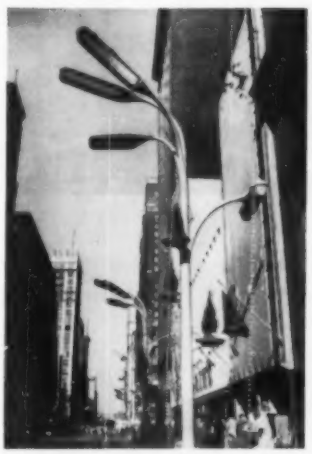
1926—3½ footcandles.

1958—14 footcandles.

State Street, Chicago, Relighted

BACK IN 1926, State Street, Chicago, was relighted with what was then one of the most advanced street lighting systems, custom-designed lighting units with two 2000-watt Mazda lamps mounted on 27-foot 9-inch poles. Property owners, mainly merchants, formed a duly-authorized organization to underwrite the expense of everything over the amount the city would supply for normal street lighting. This organization still operates today.

The State Street Lighting Association, whose membership parallels that of the State Street Council but which is solely concerned with maintaining the lighting of the street, has added improvements to the system over the years, but in 1953 it became obvious that a new system was necessary to keep up with the times. Various types were considered and experiments made on a basis of quantity, quality and color of light. The unit finally decided upon, and put into operation in November 1958, consists of four luminaires on arms branching out from a 36-foot-high pole, each luminaire containing six high-output fluorescent lamps. The luminaires over the street are mounted at heights of 36 feet and 34 feet, the one over the sidewalk at 24 feet. Quantity of light generated by units on each pole is 223,000 lumens. The installation is designed for maintained level of 14 footcandles.



Daytime view shows position of the luminaire branches.

1958 Achievements

Planters on the poles contain decorative shrubs in detachable pans painted in blue, yellow and orange-red. Poles are limestone beige.

A radio control system turns on all lights at dusk, turns off the three lowest arms at midnight and the top luminaire at dawn.

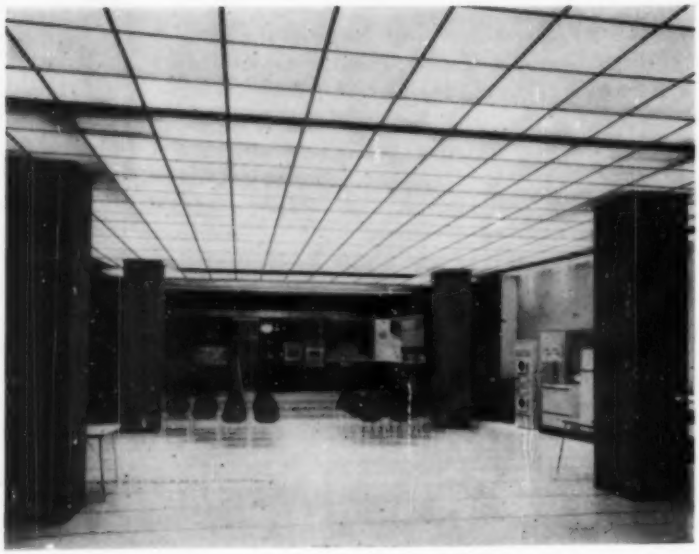
Photos and data courtesy the State Street Council, the General Electric Co., and the Union Metal Manufacturing Co.

High Levels In Offices . . . more

NOT ONLY the president (see October 1958 IE, page 536) but lesser employees as well enjoy the benefits of high-level quality lighting in modern offices. In the new quarters of the Cleveland Electric Illuminating Co., shown here, various types of luminous ceilings are one method used to achieve or improve upon the new IES recommended levels. In other areas, not shown, the company used other techniques including fluorescent troffers, recessed incandescent downlights and cold cathode perimeter lighting. Dimmers and separate switching of circuits provide flexibility of control.

Electrical engineers' room has lighting typical of most of the offices on the fifth floor of the Cleveland utility. An average of 150 footcandles is supplied by 96-inch T12 and T8 standard cool white lamps above the corrugated plastic ceiling. Acoustical baffles are on 4- by 8-foot centers. Gradation in illumination level from this type area to the 50-footcandle elevator lobby is through 80-footcandle corridors. The company has noted a 5 to 20 per cent increase in employee productivity with the new higher levels.

Eye tasks in the auditorium are often similar to those in an office, and suitable lighting has been provided. A variety of lamps—standard cool white, deluxe warm and deluxe cool, white, blue and pink 150-watt reflector type—are mounted behind the aluminum hexagonal-celled ceiling panels. Levels are up to 300 footcandles.



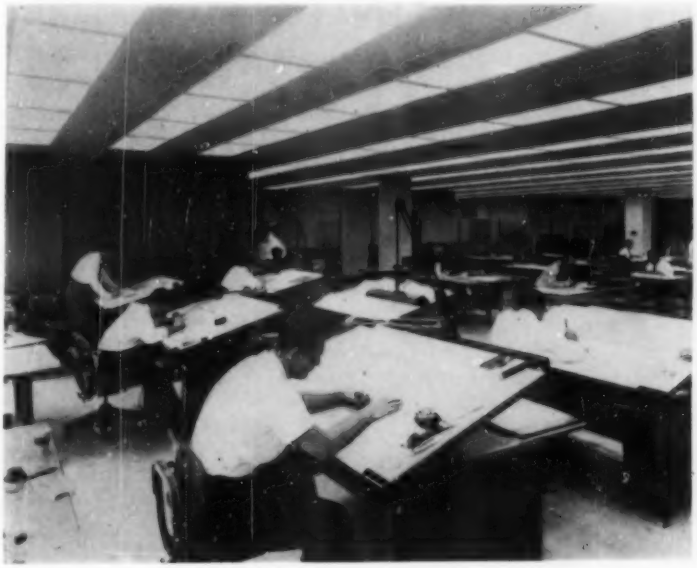
All Cleveland Electric Illuminating Co. office photos, except that at right, are courtesy of Parade Studios, Cleveland. Photo at right by Lou Moore, Cleveland.

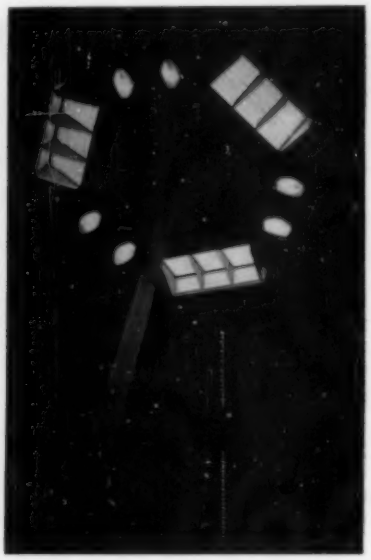
Corridor and secretarial office on the sixth floor (left) of the Cleveland company receive 170 footcandles at desk level from 72-inch warm white slimline lamps mounted 5 inches above the ¼-inch thick plastic ceiling. Wood baffles are 4 inches thick. Level is 275 footcandles in the office of the president's secretary (right). Ninety-six 72-inch warm white slimline lamps are used.

1958 Achievements

. . . and still more

ANOTHER utility which practices what it preaches is Columbus and Southern Ohio Electric Co., whose new office building in Columbus uses a total of 3460 3- and 4-lamp troffers. Troffers in the area shown are on 6-foot centers with a resultant 170 footcandles maintained. Shielding "doors" are removable for maintenance. Photo and data courtesy of Smitheraft Lighting, Chelsea, Mass.





Lighting a Plaza with ONE TALL UNIT

1958 Achievements

IN THE official Progress Report on developments during the past year, mention is made (page 38) of a new giant-size street lighting luminaire in Munich, West Germany. This luminaire was presented to the city on the occasion of its 800th anniversary and has been erected in the middle of one of the city plazas.

The luminaire uses three of the new 20 kw 550,000-lumen xenon lamps and six 400-watt improved-color mercury lamps in a hexagonal unit. The xenon lamps are in reflectors with parabolic aluminum grooved mirrors and are each approximately 6¼ feet (1.9 meters) long. The mercury lamps are in oval reflector units and are kept burning all night long, the xenon lamps being turned off at midnight when traffic lessens. Average illumination in the nearly ½-acre area is about 10 footcandles (100 lux).

Igniters generating an ignition voltage of 20 kv are built in to start the xenon lamps. Excessive thermal stress on luminaire components is prevented by a blower system which renews the surrounding air several times per minute. Feeding and control cables end in a control cabinet located at a distance of about 98 feet. In addition to the necessary switch gear, the cabinet contains the chokes and compensating capacitors for the xenon lamps.

The luminaire has a maximum diameter of about 16½ feet; its total weight is approximately 1.2 tons. It is mounted on a one-piece concrete pole with three screwbolts at angles of 120 degrees. The pole has a total length of 105 feet, embedded about 6½ feet in the ground. Diameters at base and top are about 2¼ feet (70 centimeters) and 8 inches (20 centimeters) respectively. Weight of the mast is 9.6 tons. Maintenance is by an extension ladder mounted on a truck.

Photos and data courtesy of Dipl.-Ing. W. Schmidt, chief engineer with Osram G.m.b.H., Munich, and Dipl.-Ing. R. Lehmann, engineer with Siemens-Schuckertwerken, Erlangen.

High Levels In Industry

By D. J. O'NEILL

CERTAIN areas in industry are among those where the new IES recommended levels of illumination show marked increases over previous standards. In machine shops, for example, a comparison of recommendations for bench and machine work shows:

	1952 American Standard Practice for Industrial Lighting	1958 "New Footcandle Tables" August 1958 IE
Rough	20	50
Medium	50	100
Fine	100	500**
Extra Fine	200*	1000**

*Plus supplementary illumination.
**Obtained with a combination of general lighting plus specialized supplementary lighting.

High-output sources make these levels feasible, but the quality story depends upon fixture design. Basic desirable characteristics of a luminaire for low-bay areas may be stated as:

(a) Deep shielding of the light source,

(b) Efficient output in useful downward zones,

(c) Upward component to relieve contrast between luminaire and background,

(d) Simple mechanical construction and minimum maintenance requirement.

To provide a "laboratory" demonstration of how a machine shop can be lighted to the new levels, an installation was designed with luminaires mounted 11 feet 2 inches above the floor. This is within the mounting-height range where efficient control of high-output sources is most critical. Units are deep open-bottom open-top prismatic glass reflectors with 400-watt BT-37 improved-color mercury vapor lamps. Lighting outlets are served from 220-volt 60-cycle 3-phase circuits. All equipment is standard and available from the manufacturers' catalogs.

In this installation, 80 luminaires are used to provide an average initial level of 190 footcandles, for tasks at lathes, planers, milling machines, power hacksaws, drill presses, tool grinders, band saws and thread cutters, on materials of about 60 per cent reflectance. Spacing of outlets in the 5100-square-foot area is 11½ by 12½ feet and 12½ by 14 feet on centers, with additional outlets on diagonals of these centers.

Initial illumination levels taken at specific locations were:

Tool rest on grinder and at work positions on five lathes	230 fc
Tools on three milling machines	200 fc
Work positions on two planers	175 fc

Differences in these three sets of readings are accounted for by obstructions of machine parts on some milling machines and planers.

It is possible at a future date to install an additional 36 luminaires at existing outlet positions. With these, average initial levels would be increased to about 265 footcandles.

New recommended footcandle levels in machine shop installation in Newark, Ohio

AUTHOR: Holophane Co., Inc., New York, N. Y.

Reaching for the Sun

Prepared by the Committee on Progress of the Illuminating Engineering Society

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A. R. Jaeger	H. A. Williams

The Illuminating Engineering Society Progress Report for the year 1957-1958 has the theme of "Reaching for the Sun." This is particularly appropriate for this year's report because it is symbolic of man's continual striving toward a new and better tomorrow. In the field of rocketry, for example, we are still reaching for the moon; however, the lighting industry has long since left moonlight far behind and is now reaching for a new objective — sunshine.

In this banner year of 1958, there is an abundance of unique new products, new techniques and new concepts. This presents an ever increasing opportunity to achieve the now clearly defined objective of *providing the best seeing for every individual at all times — whether at work, at home or at play.* This poses an inescapable challenge to every one in the lighting profession to understand and be responsible for communicating, to all who use light, the methods of creating the markedly improved lighting conditions that the user so urgently needs. Only if each of us accepts this challenge will the parade toward the sun proceed at the accelerated pace that is to the best interest of the user and to every segment of the lighting and power industry as well. Is there reason to proclaim that there is something special about this year? We think there is.

For easy seeing tasks we see clearly throughout the range of natural lighting conditions; from twilight of one footcandle to full sunlight of 10,000 footcandles or more, but the optimum is in the range of 500 to 1000 footcandles. For difficult seeing tasks, however, even full sunlight may not provide easy seeing. The researches of Dr. Blackwell, and others, reported this year provide vast amounts of new data which establish the lighting conditions which provide for best seeing. Other researches on the effect of environment indicate that when we relax, the lighting environment that we prefer depends largely on the mood of the moment, and we enjoy lighting ranging all the way from twilight to full sunlight.

As our knowledge from experience, and more importantly from research, grows, and as economics permit, IES recommendations change. In 1952, for example, industrial recommendations ranged from 10 footcandles to 500 footcandles, depending on the difficulty of the task. This year these recommendations are increased about two-fold, ranging

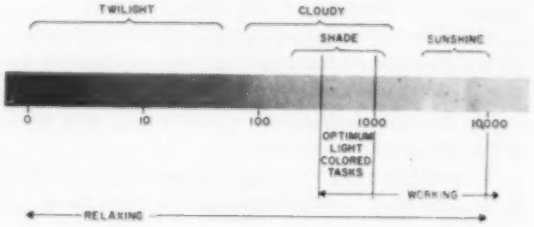


Figure 1. Range of natural lighting conditions from 1-10,000 footcandles, showing optimum working conditions in the 500-1000-footcandle range.

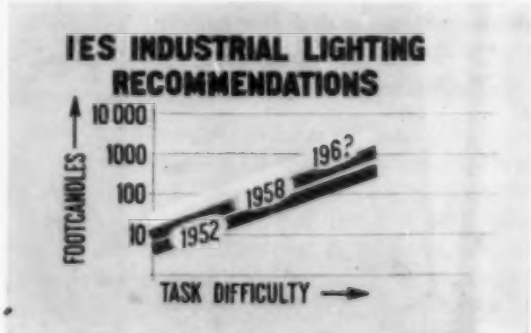


Figure 2. Increases in industrial lighting recommendations from 10-500 footcandles in 1952 to suggested levels of 20-1000 footcandles in 1958, and further increases seen for the future.

Approved by the Council of the Illuminating Engineering Society, December 11, 1958. A Transaction of the Society.

from 20 footcandles to 1000 footcandles — and there are clear indications that these values are conservative. Perhaps in the '60's these recommendations will be doubled again, on the basis of further research and changes in economic conditions which will then show more user benefits at these higher levels.

It is convenient to visualize this evolution as a stairway, with each step representing a doubling of the lighting level of the step below. Today we are about halfway up the stairway — the stairway to sunshine. One hundred footcandle levels are typical of today's recommendations for most installations. Many users, on their own initiative, have

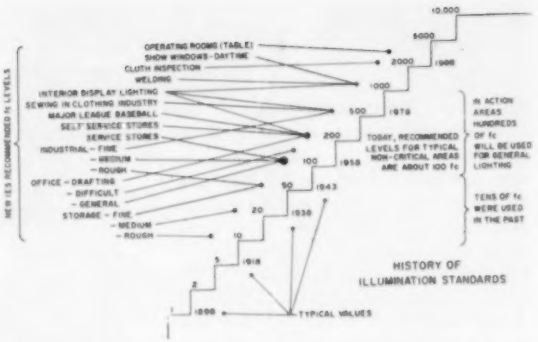


Figure 3. Increases in IES recommended levels of illumination through the years.

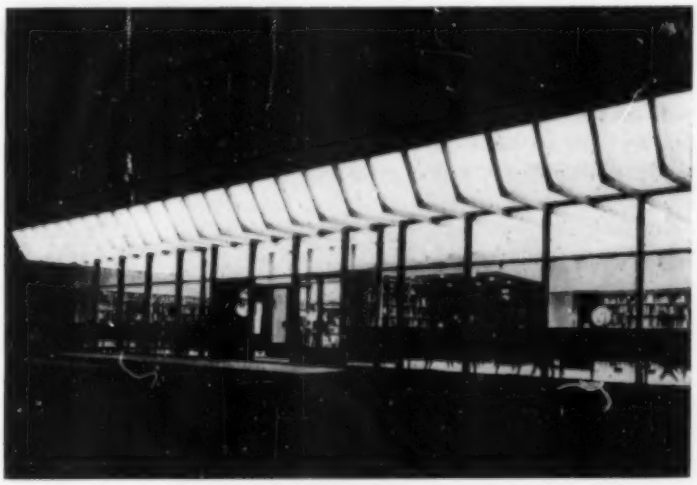


Figure 4. High levels in a quiet library . . .

in heavy industry . . .

and in a junkyard.

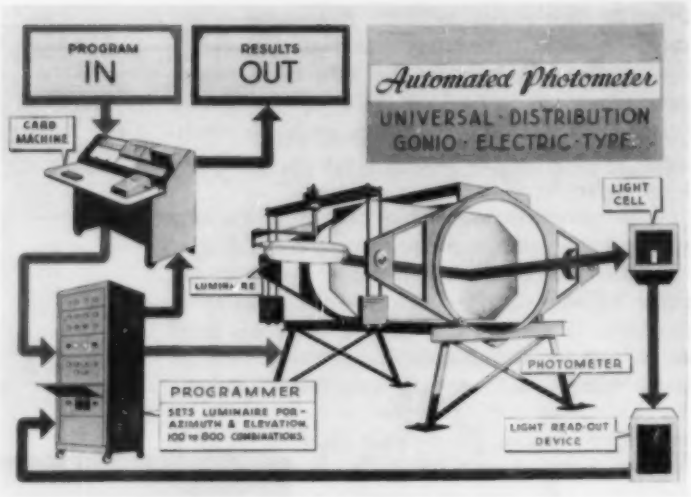


Figure 7. Functional Diagram. By following the arrows, the path of input information on cards can be traced through card reader and program unit to the photometer structure drive motors. Light output from luminaire is measured by the light cell; this information is then sent to the light readout device, then to the program unit and finally to the card machine where data are punched in the output card.

gone another step or two up our stairway to the sun, and this applies to all fields of lighting. From the heaviest industry to the quiet library, levels of 100 footcandles or more have proven their worth. Even junkyards have found it advantageous to use this amount of light.

Lighting Measurement

As the papers which were presented at the Toronto Conference eloquently testify, our researchers have made major contributions to the lighting industry during the past year. Important new techniques and new devices have become available. A large goniophotometer has been developed for fully automatic photometry of lighting units. Punched cards program this device, dictating angles for 600-800 readings, which gives the results on a second stack of cards. When this second deck is fed into a standard IBM calculator, the candlepower and lumen values on the test unit appear on a printed tape.

Another type automatic photometer has also been developed. The programming of this photometer is accomplished by means of two punched tapes, one to control the lateral orientation of the luminaire, and the other to control the vertical orientation of the selector mirror.

A Discomfort Glare Evaluator was also introduced this year which allows investigations of

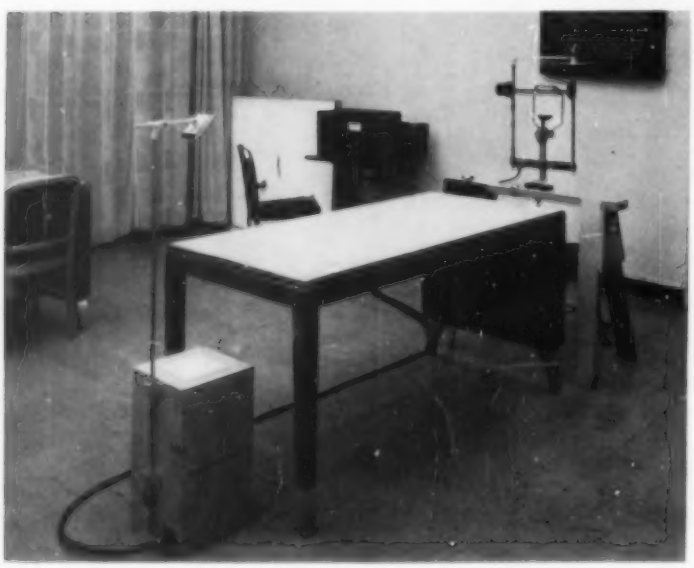


Figure 8. Discomfort Glare Evaluator showing control units and test sources.

practical situations from low level street lighting to modern 500 footcandles interiors.

New Lighting Materials

As we continue our climb towards more adequate footcandle levels, the materials used in lighting units become more important.

In the field of polystyrene plastics, we have noted marked improvements. Available in a wide color selection, they now offer better stability to ultraviolet light. It is now possible to obtain molded louvers as large as 2 x 4 feet in a single piece. Quite possibly this is a result of the increasing number of luminous ceiling and large area luminaires that are being installed today.

An application of specular aluminized plastic in a louver of wedge design produces extremely low brightness above the 45-degree cut-off angle. Here is a means of having dark luminaires regardless of lamp output when viewed at angles above 45 degrees. The brightness appearing on the blades is that which is reflected from walls and other vertical surfaces. This provides a unique opportunity for controlling amount, color and pattern of louver brightness.

A versatile new reflex-reflecting material that withstands outdoor service and will be especially useful for temporary airstrips was introduced this year. One unique aspect of this material is that even though it is completely wet, such as in a rain storm, it still has a directional reflectance of 50 per cent of incident candlepower value.

Introduced this year was a reversible prismatic eggcrate louver. This louver is of molded clear plastic and provides two distinct light patterns. With the apexes down the light is directed in a wide distribution; with the apexes up the light distribution is narrower.

An aluminum louvering material of small-cell size was made available. The louvers are available in various sprayed pastel colors and anodized aluminum. They are also available in very large sizes, as much as 2 by 20 feet.

A light-controlling panel of pale opal glassware is now on the market. It combines a high degree of prismatic action with slight diffusion for smooth appearance and hiding the luminaire interior.

Also making its debut this year was a new reflector sheet. This sheet achieves its high reflectivity by virtue of an evaporated aluminum coating on polyester film laminated to the surface of a mill-finish sheet of aluminum or steel. The completed sheet withstands outdoor service. This new material has been used for reflectors in some of the luminaires which will be discussed later.

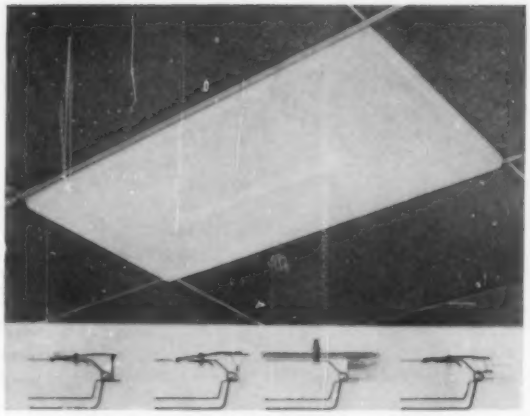


Figure 9. Troffers are becoming shallower and shallower. This troffer recesses only 1⅜ inches — an answer to the absolute minimum cavity and to the low ceiling conditions so often dictated by the economics of present day construction.

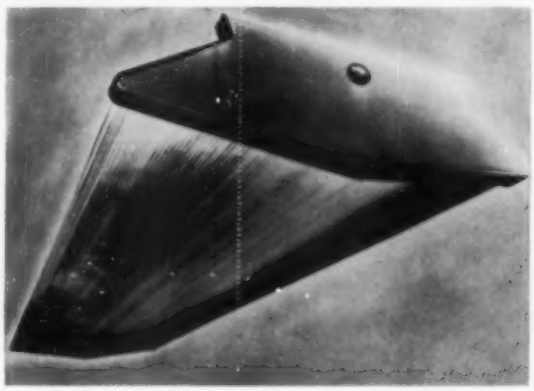


Figure 10. Surface mounted unit with clean lines. One piece extruded acrylic or polystyrene refractor provides luminous wrap with brightness controlled not only in the viewing zone but also on the ceiling.

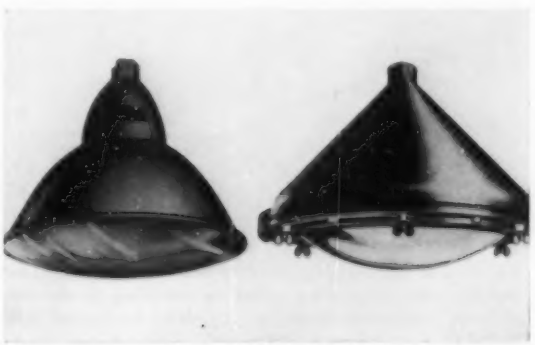


Figure 11. All purpose dust-tight prismatic reflector-refractor industrial unit at left, and dust-ignition proof luminaire for mercury lamps at right.

Figure 12. Explosion proof luminaire using mercury lamps for hazardous location.

New Lighting Units

To meet the challenge of higher, more adequate, footcandle levels, many new luminaires have been introduced. Some are unusual in design, some simplify installation, and others have improved maintenance characteristics. However, the one feature that has been emphasized by most manufacturers is comfort. A few of these improvements in the direction of more comfort are better shielding, more upward light, and more improvement in louver designs.

New Sources

If our effort towards reaching the sun is to be successful, we must have new and improved light sources. These sources must produce the lumens which will enable us to obtain the lighting levels which are needed today. During the year 1957-

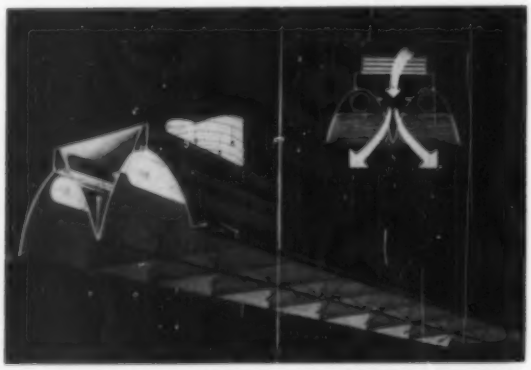
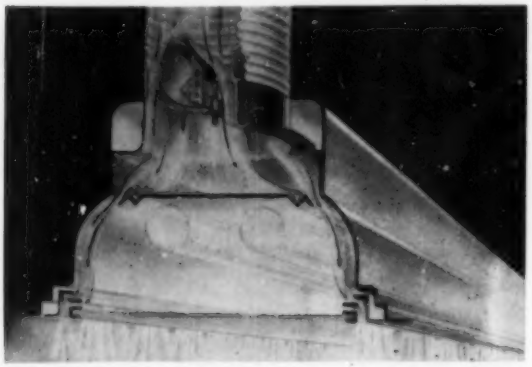


Figure 13. These units make possible uncluttered ceilings by combining comfortable illumination and air distribution into one attractive functional unit. Luminaire in photo at left circulates air through the center louver; unit in photo at right circulates air around the frame which holds the glass louver.



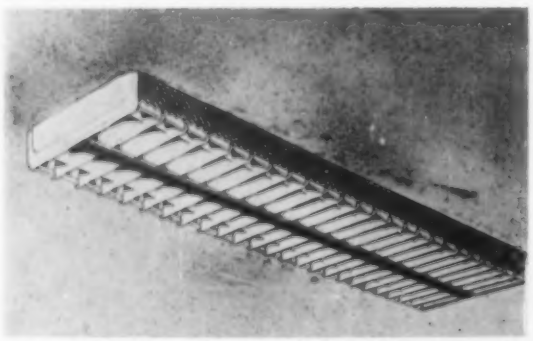


Figure 14. Method of providing better shielding is used in this unit. 45-degree crosswise shielding is obtained without increasing depth, by a central horizontal light baffle of configurated polystyrene. Cross louver blades are held by plastic rail supports. Translucency of side rails gives side panels a luminous bottom edge with no dark strips to mar the appearance.

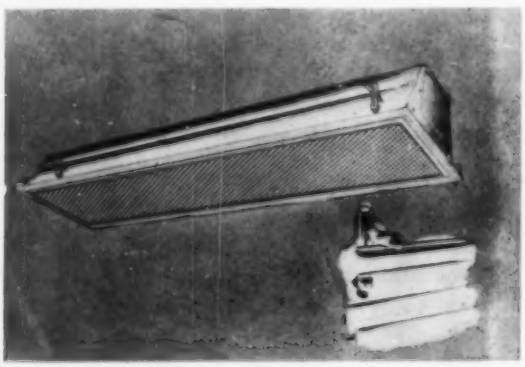


Figure 15. New method of installing flange troffers, eliminating the use of "U" brackets, has been introduced this year. These supports are installed on the housing and are adjustable for use on virtually all types of furring construction. Leveling of each support can be made inside the housing.

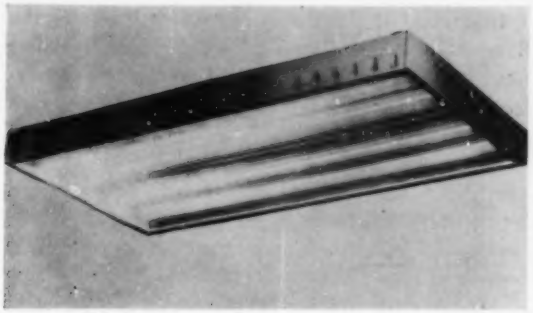


Figure 16. Color accents are added to this steel surface-mounted unit. The user is given a selection of three colors in plastic strips to add color to side panels.

Figure 17. Unit with high reflectivity aluminum designed for extra high output lamps. This luminaire has been used for runway strip lighting, turnpike lighting.

1958, there was much progress made in this field.

Many new additions were made to the filament line. A new filament bulb shape was introduced which provides a change in styling of household light bulbs. With this lamp the consumer market now has an opportunity to consider the esthetics of bulb shapes. Incandescent 1000-watt lamps equipped with CC-8 filaments appeared in the RB-52 and the PS-52 bulb shapes. With increased lamp lumens and higher coefficients of utilization, these lamps provide more light on the work surface.

A new lamp for automobile instrument panels was introduced. This is a 12-volt flashing indicator lamp with a built-in thermal flashing element. Earthmovers and other heavy machinery can now be equipped with specially designed PAR-46 sealed beam units for 6-, 12-, and 24-volt circuits. These lamps are made as floodlamps with appropriate beam control, and filament shielding is provided for best visibility where dust clouds are encountered.

Two additions were made to the growing family of PAR aircraft lamps. A 1000-watt PAR-64 aircraft landing lamp with approximately 600,000 beam candlepower was made available. Also introduced in the aircraft field was a PAR-56 lamp operated at 6.6 amperes and 200 watts. The luminaire for this lamp is installed within the airport runway, and is now in use at some Air Force installations.

In the photographic field, many new sources were announced during the past year — 375-watt and 300-watt photoflood lamps are now available in the R-30 bulb. This type of lamp will allow a reduction in the size of the "light bars" that are now used. New 1200-watt projection lamps can now be used in well ventilated projectors originally designed for 1000-watt lamps. By using this lamp, 15 to 20 per cent more light is delivered to the screen.

Figure 18. (left). New filament bulb shape introduced this year.

Figure 19. (right). New internal reflector projection lamp has simplified projector design by eliminating the need for usual external reflector and condensing lens. 150-watt lamp of this type produces screen illumination equivalent to 500-watt projection lamp when used in an 8 mm projector.

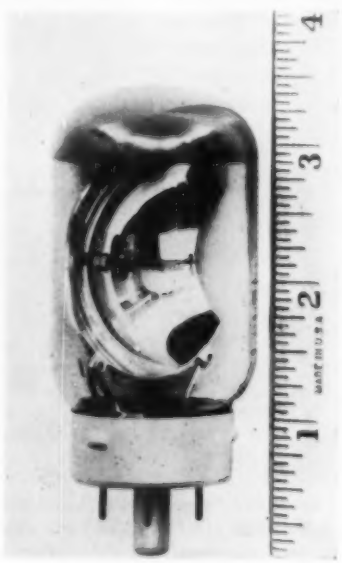


Figure 20. Photoflood lamps of 300- and 375-watt sizes are now available in the R-30 bulb. This type of lamp will allow a reduction in the size of the light bars that are now in use.

Simplification of projector design is accomplished by using a new internal reflector projection lamp which eliminates the need for the usual external reflector and condensing lens. In an 8-mm movie projector a 150-watt lamp of this type produces screen illumination which is approximately equivalent to a 500-watt projection lamp.

Photographic flash lamps are now twice as powerful because of the use of a new metallic foil, zirconium. Because of this, substantial reductions may be made in the size of flash equipment without sacrifice of light output.

A special type of "long duration" photographic flash lamp now makes possible a portable light source for battery driven high speed motion picture cameras. The light duration of this lamp is 1.75 seconds. Another new light source for photographic purposes is a pulsed xenon arc lamp in a T-3 quartz tube. Used in photo reproduction, this lamp is pulsed 120 times per second and looks like a continuous burning source.

1958 marked the Twentieth Anniversary of the fluorescent lamp. The tremendous progress that has been made in this field can be seen by comparing the light output of the first fluorescent lamps to the output of today's fluorescent lamps. The cost of light using fluorescent lamps is lower today than ever before and indications are that this downward trend will continue. For example, during 1957-1958 several manufacturers announced increases in light output of various fluorescent lamps.

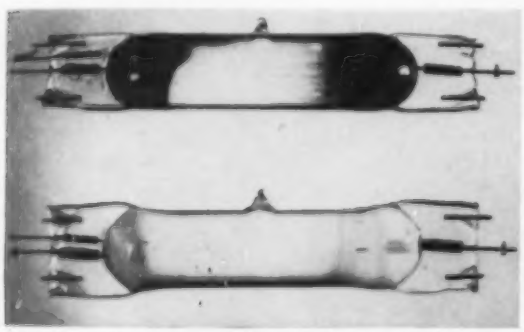
Another contributing factor to this lower cost of light is the extra-high-output fluorescent lamp. These lamps are finding even greater customer acceptance and usage. This is illustrated later in both interior and outdoor applications.

Fluorescent lamps have been improved to reduce end blackening and lessen lumen depreciation, thereby providing more light during the life of the lamp.

A new family of low wattage T-5 special rapid-start fluorescent lamps has been developed — operated on 400-cycle hermetically sealed ballasts and using dimming circuits, these new lamps provide flexible lighting for tomorrow's jet aircraft.

Substantial increases in mercury lamp lumen maintenance have been made possible by new developments in electrode design and emission materials. As much as 65 per cent more light is produced after 8000 burning hours than from present lamps of the same size and wattage. The useful life of these new lamps is estimated at 9000 hours.

A new 400-watt mercury lamp for 3.2-ampere straight series street lighting has been developed. This lamp has a built-in construction feature (patent pending) that protects the socket and fixture from arcing at the time of normal lamp failure or abnormal voltage surges. This feature eliminates the need for external film cut-outs. In this lamp one lead wire is enclosed in a special glass sleeve and the other lead wire wraps around the sleeve.



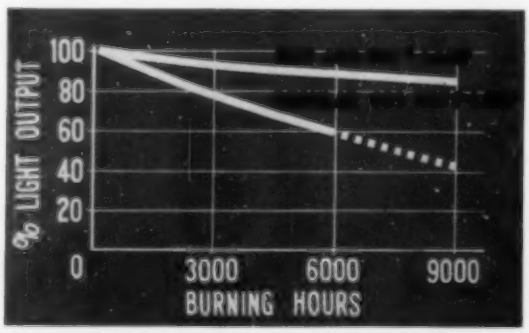


Figure 21. Lumen maintenance curve shows 65 per cent more light, after 8000 burning hours, from new cathode treated mercury lamp (at bottom in photo at right), as compared with present lamp (top) of the same size and wattage. The useful life of these new cathode treated lamps is approximately 9000 hours.

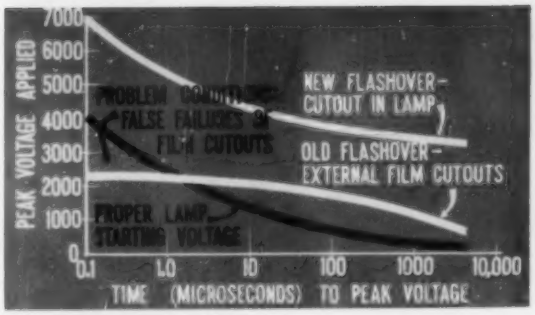


Figure 22. New 400-watt mercury lamp on straight series circuit.

When the lamp reaches the end of life an internal arc will melt the sleeve and allow the lead in wires to fuse, thus extinguishing the arc.

Outdoor Lighting

During the past year we have seen increased interest in all kinds of outdoor lighting. Fluorescent street lighting using extra high output lamps is becoming very popular; shopping centers are brighter to attract more customers; fast moving turnpike traffic is safer because of modern fluorescent and mercury lighting; signs are brighter and bigger, many using extra high output lamps; numerous commercial establishments are being floodlighted for nighttime advertising.

Examples of the progress made in this field can be seen in Figs. 23-37.

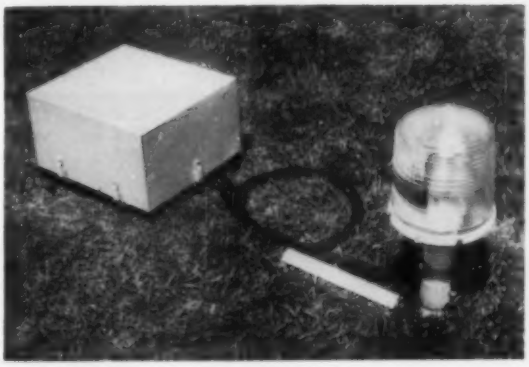


Figure 23. Aircraft circling guidance light gives steady white signal used to help control approach patterns near airports. It is mounted off runway and controlled to decrease in brightness as runway lights increase.

Figure 24. (left). Outdoor unit designed for practical or decorative lighting. Mercury, circline fluorescent and incandescent types are available.

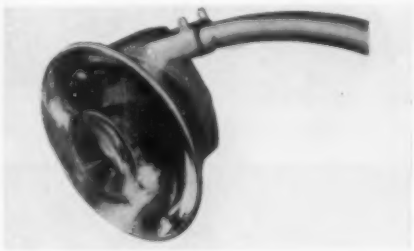


Figure 25. (above right). Uni-directional mercury luminaire. The unit incorporates a specular aluminum reflector, a special prismatic lens and built-in louvering.

Figure 26. (below right). New fluorescent streetlight designed for mounting parallel to curb. When mounted in this fashion, area of the unit is reduced at normal viewing angles which substantially reduces glare.

Figure 27. Eight-foot, single lamp units suspended on catenaries provide 10 footcandles on tennis court.

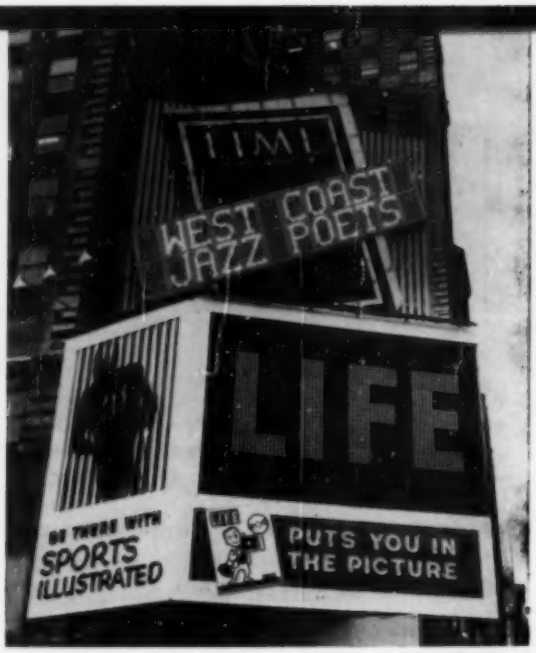


Figure 28. Time-Life sign on Times Square utilizing 4200 newly designed A-21 neck reflector lamps.

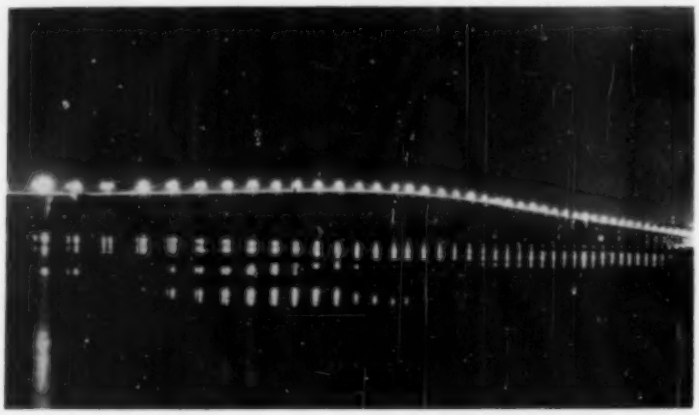


Figure 29. Mercury lamps are used to illuminate the world's longest suspension bridge.

Figure 30. World's largest fluorescent highway installation — sixteen miles of approaches to Baltimore Harbor Tunnel.

Figure 31. Brookings, South Dakota, first city in the United States to light all streets to American Standard Practice recommendations, with fluorescent luminaires.

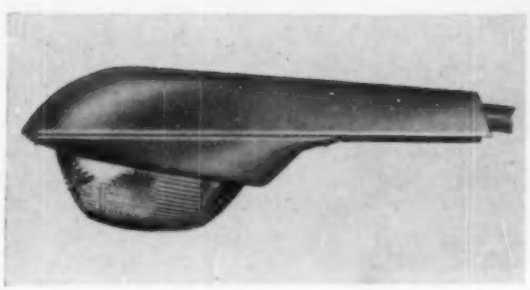


Figure 32. Mercury street lighting units with self-contained ballast.

Figure 33. Colored PAR lamps light a store front in Miami Beach.

Figure 34. Eight footcandles of mercury lighting on this street, reported to be one of the world's brightest main streets.

Figure 35. New four-way luminaire designed to shield the light from the houses on the four corners of the street intersections.

Figure 36. Mercury floodlight unit using two filament lamps and one mercury lamp. Heat from filament lamps allows mercury lamp to start in cold weather.

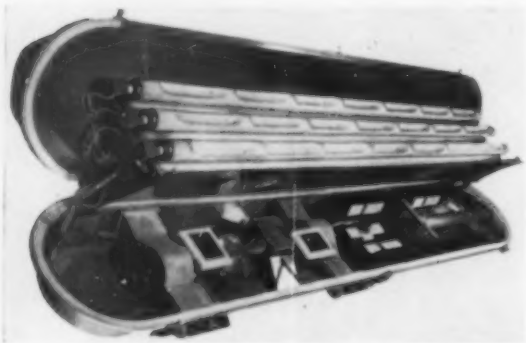


Figure 37. World's most powerful fluorescent street lighting luminaire, approximately 56,000 initial lumens. The unit is temperature regulated by two thermostatically controlled fans.

Residential Lighting

More and more home owners are realizing that light is essential to Live by as well as See by. They are finding that the beauty of the home is lost if the lighting is not adequate. This, of course, not only applies to the interior but the area around the house as well. One reason for this is the trend towards more outdoor entertaining. Outstanding examples of residential lighting are shown in Figs. 38-56.

A significant trend in the residential field is the emphasis being placed on education of home owners by extensive educational programs. Many new training materials are available.

Figure 38. Through the smooth combination of fixed structural and portable lighting in this family room-dining room area-kitchen, there is a choice of efficient work light, a pleasant dining atmosphere and lighting adapted to the variety of activities carried on in the family room. Seventeen pieces of lighting equipment are used, providing 115 generated lumens per square foot in kitchen area, and 85 in the family room and dining area.

Figure 39. Perimeter spotlights consolidate the light plan as one goes from room to room. Small spots at the entrance lead into the foyer. The dimmable fluorescent cove is accented by a three-unit pierced metal cluster in the cove center.

Figure 40. Small R-30's "wash" the walls going into the dining area. The table is illuminated with three separate luminaires suspended on cords from a ceiling track, individually switched for up and down light control. Fluorescent cove is dimmer controlled.

Figure 41. View of living room from dining area. Small perimeter spots contribute continuity to entire room.

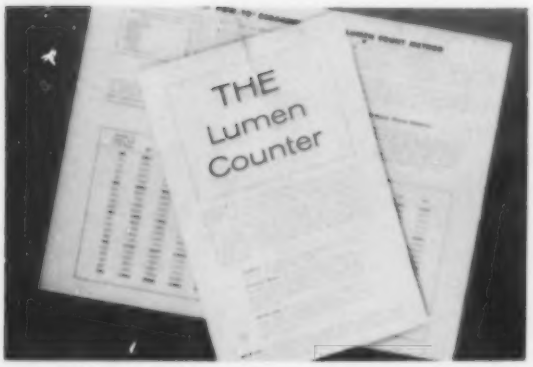


Figure 42. The "Lumen Counter" is a new convenient "How To" method of planning home lighting. This rule of thumb system takes some of the mystery out of home lighting for the layman.

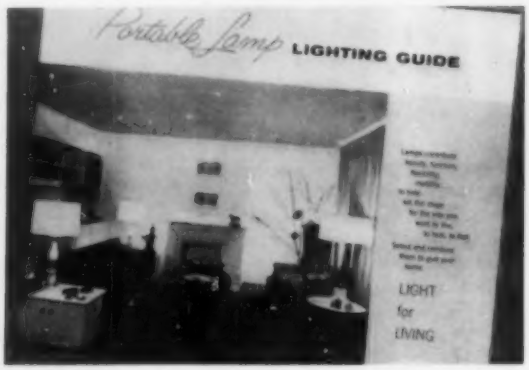


Figure 43. One of the effective tools developed during the past year was the Portable Lamp Lighting Guide which illustrates how to fit portable equipment into the home lighting plan.

Figure 44. A new pamphlet full of Christmas lighting ideas including the most recently developed light sources.

Figure 45. Practical ideas for outdoor areas around the home are given in this new pamphlet.

Figure 46. The Medallion Home portion of the "Live Better Electrically" program included standards for fixed lighting which are based largely on the IES Recommended Practice of Residential Lighting.

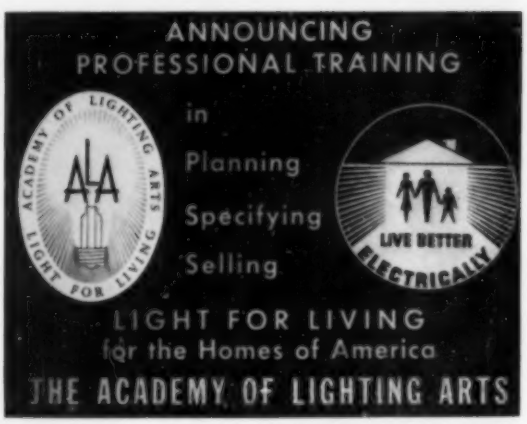


Figure 47. Recently announced is a professional training course covering the planning, specifying and selling of "Light for Living" to the homes of America called "The Academy of Lighting Arts." The course consists of twelve two and a half to three-hour sessions, and will graduate "Certified Residential Lighting Consultants" with training in lighting and seeing fundamentals.

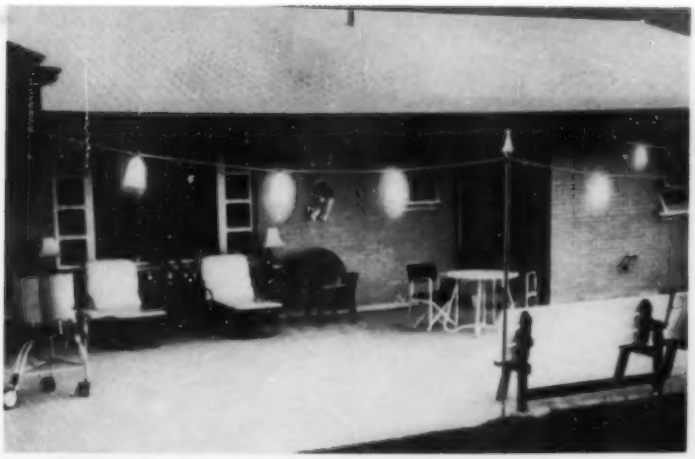


Figure 48. String of seven lanterns available in various colors. Can be used for patios, pools, gardens, etc.

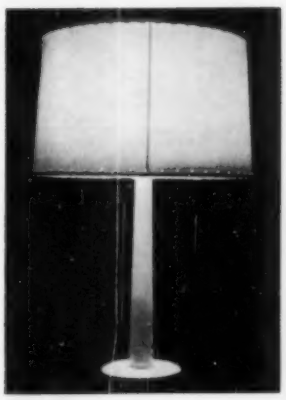
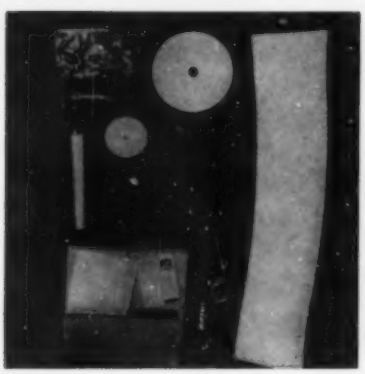


Figure 49. Lamp at left, using a 50/200/250-watt lamp, designed for study and reading was made from the "do-it-yourself" lamp kit shown below.

Figure 50. This four-foot diameter plastic bubble is for commercial and residential application, a lighted satellite for a dramatic touch.



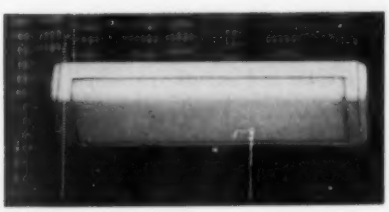


Figure 51. Newly designed wall bracket can be used for mirror, bed or stairway lighting.

Figure 52. (left). Three cylinder unit of ribbed pattern styrene which produces a white on white effect when lighted.

Figure 53. (right). This luminaire is 24 inches square with a plastic diffuser. It uses one 32-watt and one 40-watt circline lamp.

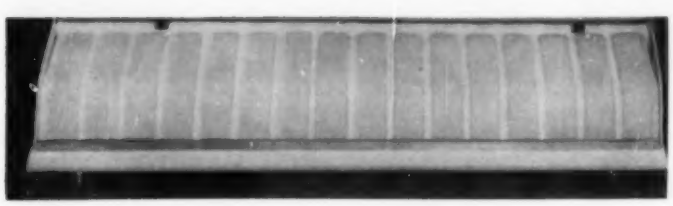


Figure 54. Luminous unit styled in vinyl plastic and aluminum. It can be used as a valance or cornice.

Figure 55. Drawing below shows detail of specially designed custom skylight luminaire for this beautiful stairway. Skylight is eight feet in diameter and is lighted, for nighttime effect. The center 300-watt lamp provides downlight through glass lens and indirectly illuminates dome cavity. Eight 150-watt PAR lamps on adjustable sockets create lighting level comparable to daylight effect.

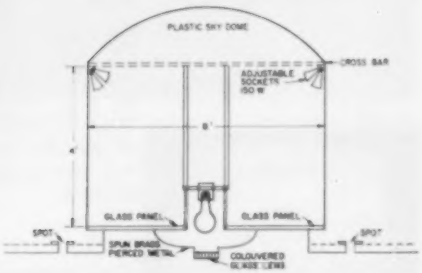


Figure 56. In this living room, used largely for entertaining, the drama of light plays an important part. The lighting in both the freeform troffer and above the draperies may be varied as to color and amount. Accent lighting is provided by the recessed R-40 downlights.

Figure 57. Self-ballasted mercury lamps in bank lobby.

Interior Application

Acceptance of much higher levels for all fields of interior lighting is the most important trend of 1958. For example, installations of several hundred footcandles are used in many industrial and commercial establishments. The trend, as pointed out earlier, has always been toward higher footcandles. However, this trend has been greatly accelerated during the past year. There are many factors which have contributed to this; among them are: better designed luminaires, extra-high-output fluorescent lamps, lower cost of light. However, the main and most important factor is the benefits which the user is receiving from these higher levels of illumination. Figs. 57-77 show some typical examples of modern lighting installations.

Figure 58. Unique direct-indirect system in a bank conference room.

Figure 59. Perimeter lighting of a bank executive office.

Figure 60. Interesting pattern achieved in a bank lobby. This lighting system is operated on high frequency.

Figure 61. 400 footeandles are provided by a floating panel luminaire in this shoe store. Not only a comfortable lighting system but also an attractive one.

Figure 62. A dramatic display in a business machine showroom with indirect lighting through the floor.

Figure 63. 800 footeandles are produced in this show window by fluorescent and incandescent lamps.

Figure 64. A private office in which 350 footcandles are provided with the added benefit of an attractive color treatment.

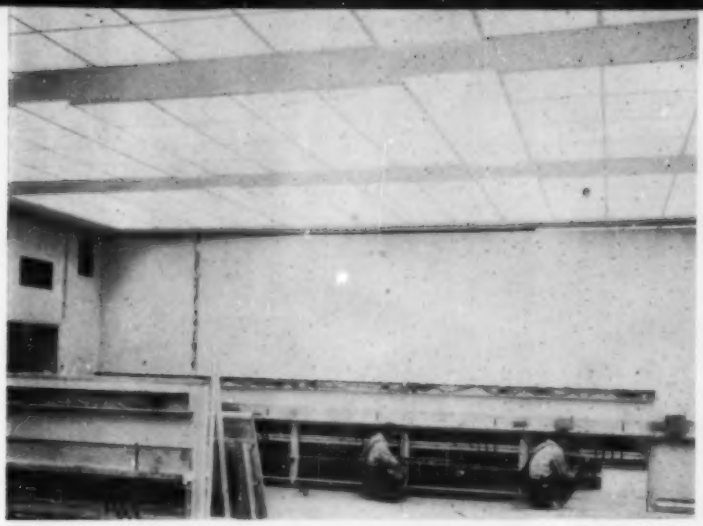


Figure 65. Laboratory with 125 footcandles from floating panels. Spacing makes provision for future partitioning if desired.

Figure 66. Laboratory office with 170 footcandles from eggcrate louvered units.

Figure 67. (left). Comfortable 600-footcandle installation from luminaire with new wedge-type aluminum louvers with 45-degree shielding lengthwise and crosswise.

Figure 68. (below). 425 footcandles in utility company executive's office.

Figure 69. Steel fabrication area with 100 footcandles.

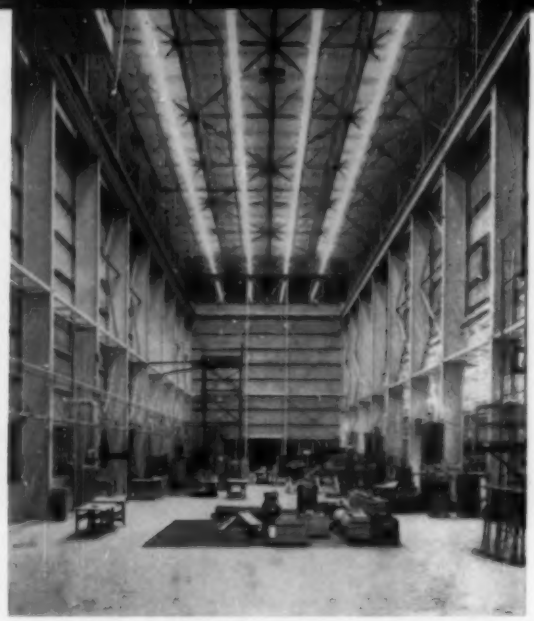


Figure 70. General lighting in atomic energy plant is provided by rows of two-lamp extra high output lamps on ten-foot centers, 67-foot mounting height.

Figure 71. 200 footcandles of quality lighting is provided for this bookbinding operation.

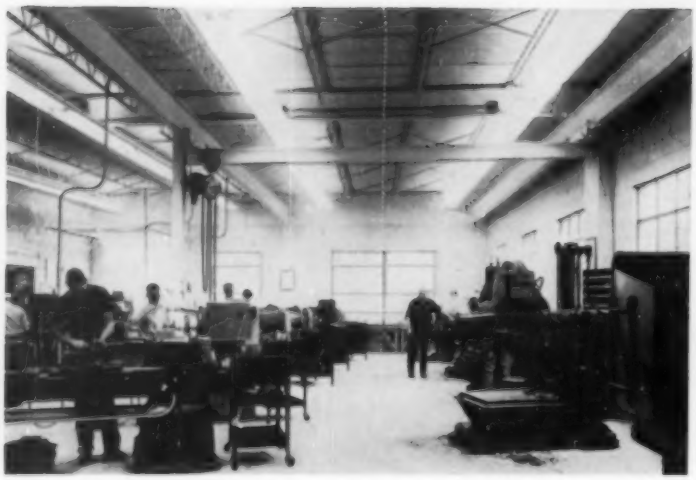


Figure 72. 150 footcandles in this machine shop eliminates need for local lighting.

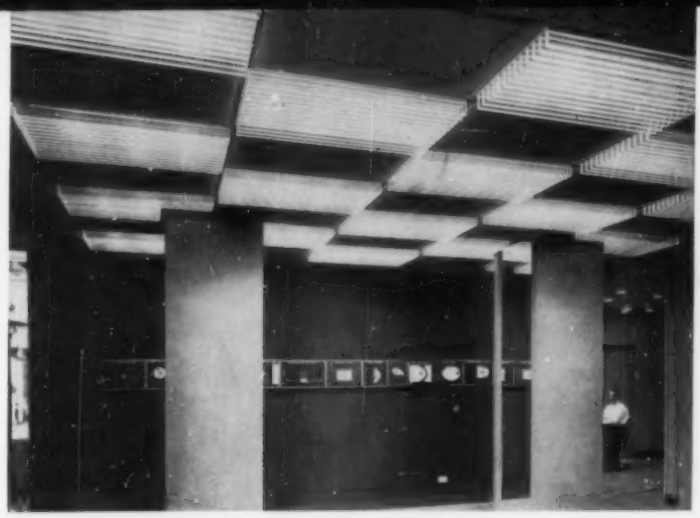


Figure 73. Decorative checkerboard lighting in reception lobby of the Chicago Lighting Institute — edge lighted plastic.

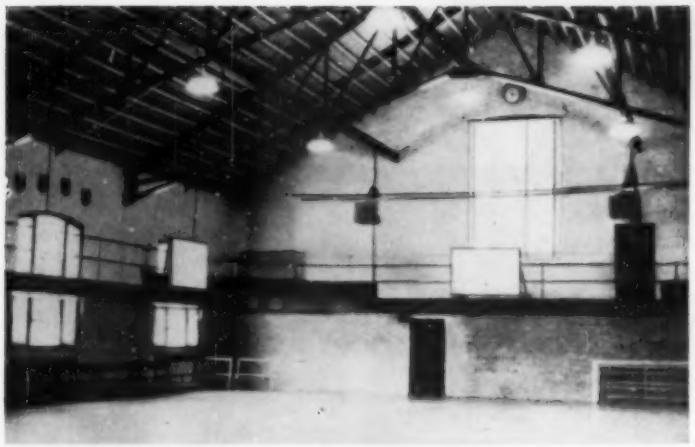


Figure 74. Gymnasium lighted with self-ballasted mercury lamps.

Figure 75. In addition to producing an adequate level of visually comfortable illumination, these luminous wall panels produce a feeling of modern spaciousness.

Figure 76. The lighting in this auditorium was achieved by a uniquely designed area luminaire which uses prismatic lenses.

Figure 77. Bowling alley with 200 footcandles. The lighting is adequate for TV cameras.

Foreign

Progress has not been limited to the United States. As can be seen in the illustrations, there has been much progress in lighting all over the world. A good example of the emphasis being placed on lighting can be seen at the World's Fair at Brussels. In some cases, it seems that lighting is the feature rather than the exhibits.

Figure 78. Matsumoto Castle lighted with filament floods.

Figure 79. (left). In Munich, Germany, three 20,000-watt xenon and six 400-watt mercury lamps mounted on a 95-foot pole illuminate the whole town square.

Figure 80. Department store in Northern Europe featuring a "slit wall" pattern for attractive nighttime effect.

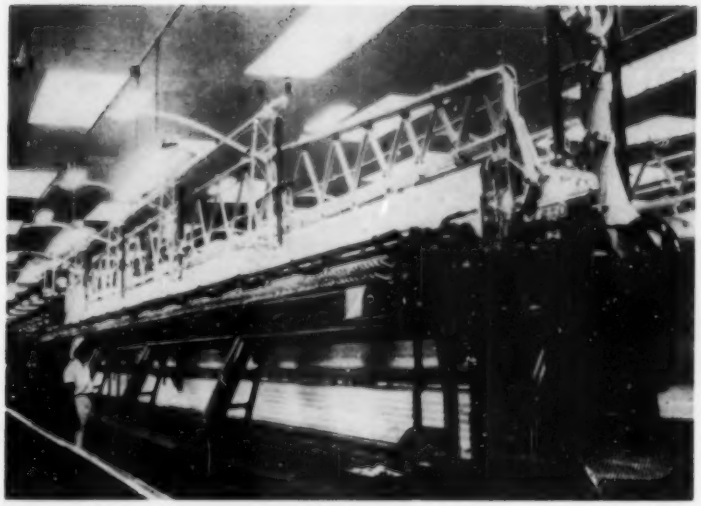


Figure 81. Japanese factory with recessed troffer lighting.

Figure 82. Mercury street lighting in Algiers.

Figure 83. Fluorescent street lighting in French Morocco.

Figure 84. The United States Pavilion at the World's Fair. The beauty of the building was emphasized by the lighting. The outside overhang accommodated reflector lamps which were designed to illuminate the circular grill work on the outer world wall from top to bottom. This lighting arrangement also provided soft general illumination around the upper area of the pavilion. This building was one of the largest circular constructions in the world. Floodlighted trees can be seen in the foreground of the picture.

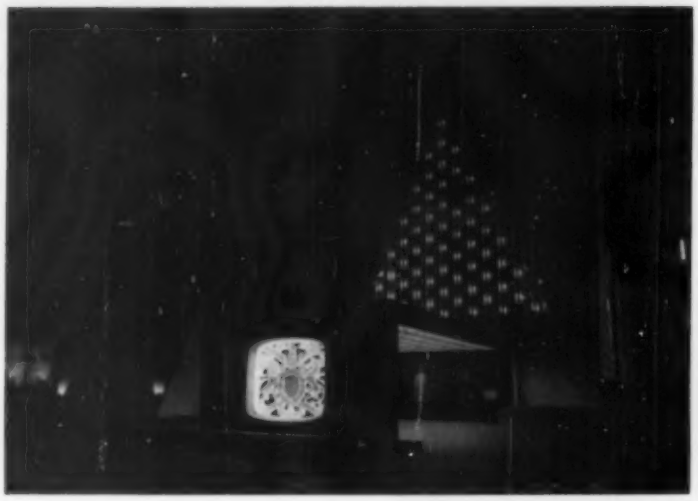
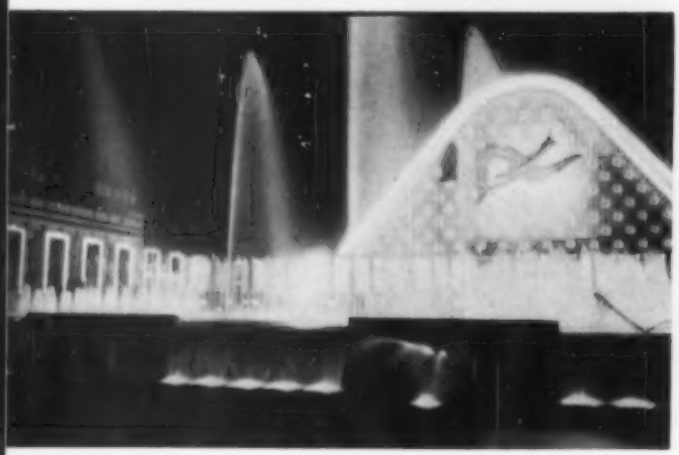


Figure 85. (left). The British Pavilion. In the foreground, the Coat-of-Arms of the United Kingdom is sculptured in Perspex (plastic), emphasized by striking edge lighting.

Figure 89. (right). The Atomium. The crystal structure was represented by spheres, eight of which were grouped around a central sphere representing the average location of the atom within the crystal. The nine spheres were interconnected by tubes, depicting the forces that link the atoms. To provide the effect of movement, the lamps on the spheres twinkled.

Figure 86. Facade of reception hall with blue stars and orange dove of peace. The fluorescent lamps are mounted between the star and the facade in such a way as to silhouette the outline of the star and create a luminous halo around it. Star was the symbol of the exposition featured throughout the grounds.



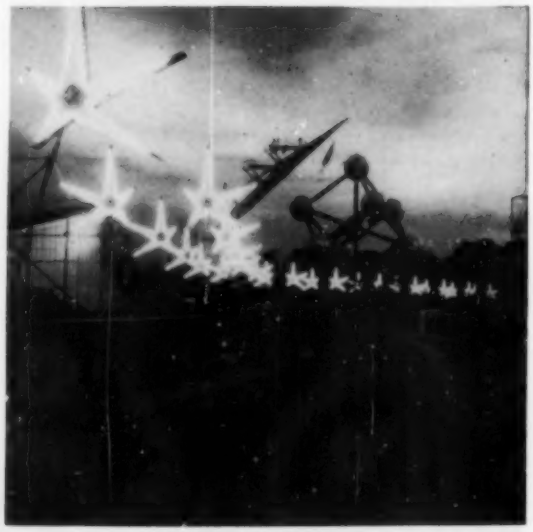


Figure 87. The procession of the Exposition Stars along the footbridge.

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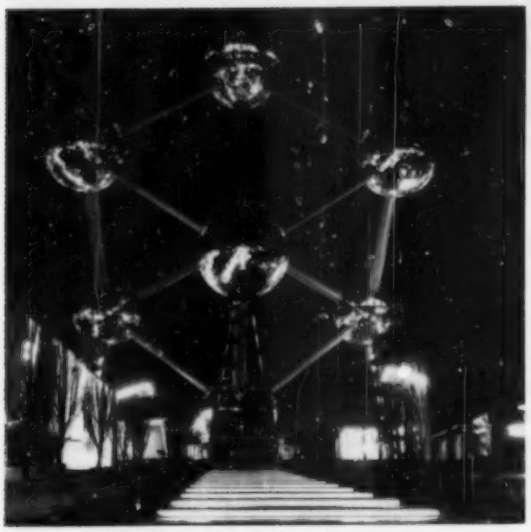
Figure 88. The Russian Pavilion was lighted to relatively high levels with a luminous ceiling in the center and bare fluorescent lamps on the sides.

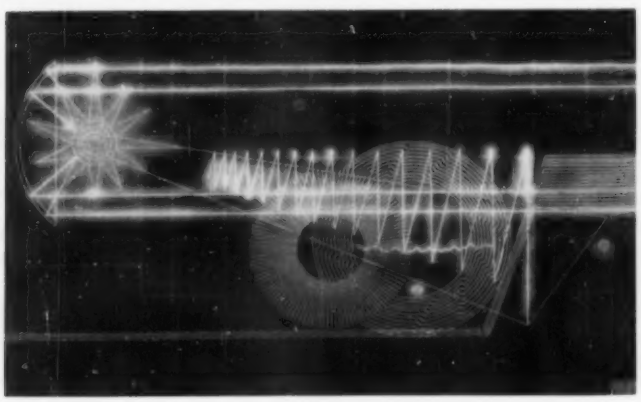


Conclusion

This report has shown the significant new developments of the fruitful year 1957-1958. The highlights of the report were: (1) the need for much better seeing conditions in all walks of life, proven by research as well as experience; (2) new materials that make better seeing easier to provide; (3) new sources of higher efficiency and better maintenance; (4) new luminaires of better design and improved appearance and performance; (5) new lighting installations showing user acceptance of higher levels, higher output fluorescent lamps, greater use of color, and more comfortable environment; (6) and finally, the new concepts of clearly establishing the optimum seeing environment. These concepts will establish a permanent goal, best human performance, towards which future research in the lighting industry can be directed.

Figure 90. (left). Luminous signs placed at main intersections helped Fair visitor find his way. The posts were made, basically, of metal tubes, curved at the top, carrying, at the inside of the curve, a directional arrow and a lighted plastic sign.

Figure 91. (below). The Electrical Power Pavilion — Sun to Power to Light. The diverse motifs lit up successively and then together: the sun and its rays, the lightning, the waterfall, while there appeared an oscillation, a turning wheel and a flashing of electrical waves.



INSTALLATION AT MUSKEGON, MICH.

Floodlighting a Sign

LIGHTING OBJECTIVE: To floodlight a building sign for advertising and identification.

GENERAL INFORMATION: This sign, which measures 208 feet in length and 27 feet in height, faces a state highway which is 1000 feet away. It also parallels a main railroad trunk line. The lettering is red, white and black. The background colors are yellow, red and black (29, 12 and 8 per cent reflectances respectively). As can be seen above, the surround is dark.

INSTALLATION: The sign is illuminated by 18 Stonco catalog No. 6401-WF luminaires, each equipped with a 500-watt PAR-64 medium flood lamp (20- x 35-degree beam spread). These 18 units are mounted 10 feet above ground on 3 poles (6 per pole) spaced 70 feet apart and 50 feet away from the sign. Each luminaire is aimed to illuminate an area of approximately 13½ feet by 23 feet with overlapping for good coverage.

Fig. 2 shows the illumination distribution after 13 months use. When lighted at night the sign can be seen from 2500 feet and is legible at 1700 feet.

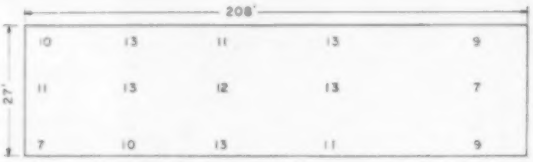


Figure 2. Illumination distribution after 13 months.

Lighting designed by James Q. Miller, Lighting Engineer, Consumers Power Co., Muskegon, Mich. and Albert Stensing, Electrical Contractor for Hall Electric Co., 1965 Sanford St., Muskegon, Mich.

Lighting data submitted by James Q. Miller, Consumers Power Co., Muskegon, Mich., as an illustration of good lighting practice and to aid in the design of similar installations.

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Design and Application of

A New High Frequency Power Source For Fluorescent Lighting

By W. H. JOHNSON
J. L. WINPISINGER
J. F. ROESEL, JR.

WITH THE ADVENT of higher wattage fluorescent lamps, ballasting has increased in size, weight and power losses. One method of reducing luminaire weight, maintaining units at a minimum practical size, and keeping heat dissipation from becoming a problem, is to operate fluorescent lamps from a high-frequency power source. The purpose of this paper is to present the latest in high frequency power source design and its integration with a complete lighting system.

The advantages of operating fluorescent lamps at higher frequencies have been known for some time. Lamps have been shown to increase in efficiency as frequency is increased up to 10,000 cycles.[1,2,3,4] Of even greater importance is the effect of higher frequencies on the lamp operating auxiliaries. Above 300 cycles, capacitive ballasting of lamps becomes practical and inductive type ballasts are materially reduced in size and weight. The overall results at higher frequencies are smaller size, lighter weight, and reduced wattage loss in the auxiliary. The lighting equipment thus becomes more efficient, lighter in weight, and minimizes the ballast heat dissipation problem. By reducing the installed wattage of a lighting system and maintaining equal illumination, two important related benefits are realized. Branch circuit wiring costs are reduced and less installed air-conditioning capacity is required to compensate for the heat dissipated by the lighting load.[5] With these obvious advantages and benefits, the biggest deterrent to greater commercial application of high-frequency lighting has been the lack of a convenient efficient power source to mate with the advanced lamp and ballast circuitry designs.

First, let us consider some of the most desirable characteristics that should be found in a power source for high-frequency operation of fluorescent lamps. The converter should preferably be static in operation, thereby minimizing maintenance. It should be noiseless, thus permitting installation conveniently close to the load and reducing the length of high-frequency distribution runs. High efficiency of power conversion throughout its load range is a must, thereby allowing maximum load flexibility and switching. The converter should operate from any commonly available distribution system and, in turn, it should be able to furnish power to any practical light source. The power source design should be versatile enough to permit operation at any fixed frequency required by a light source and its auxiliaries for optimum performance. Determination of an optimum frequency is still in the distant future and will be dependent on a number of factors. Each individual light source and its operating auxiliaries may be found to have its own optimum frequency. In the case of the fluorescent lamp, for instance, the problem of higher frequency operation with sine wave of lamp current versus medium frequency operation with square wave of lamp current still requires very careful analysis, both economic and design-wise.

The optimum system will have all or most of the qualities listed. The authors and associates visualize the optimum system as a frequency converter and ballast combination, physically and electrically small enough to supply the lamps in one luminaire. The converter would accept 60-cycle input power distributed to the luminaire and supply current-limited high-frequency output power for the number and type of light source involved. Since high frequency distribution losses would not be restrictive, the frequency could be high enough to yield maximum overall circuit efficiency.

Such an optimum system has been built and tested. It is not commercially practical today because of its high cost. Future development of semiconductor devices may make the optimum approach practical, but the day is several years away.

However, compromises among the ideal desired

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AUTHORS: Messrs. Johnson and Winpisinger, Westinghouse Electric Corp., Lighting Division, Cleveland, Ohio; Mr. Roesel, Westinghouse Electric Corp., New Products Engineering, Chesswick, Pa.
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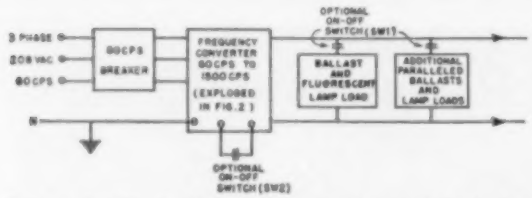

Figure 1. Block diagram of transistorized high frequency lighting system.

characteristics listed above allow a commercially practical, integrated, high-frequency lighting system today. The system, Fig. 1, consists of a transistorized static frequency converter, a high frequency power distribution line, and ballasts to start and operate fluorescent lamps.

The system is essentially a constant output voltage type. The output voltage at full load is within a few per cent of the no load voltage. Consequently, individual ballast-lamp loads may be added in parallel, up to the output power rating of the converter, without changing operating characteristics of ballasts and lamps already across the line. In this respect, the system is exactly like the conventional 60-cycle fluorescent lighting system.

Load switching is versatile. Installations requiring partial load switching may be so arranged. A switch, SW1 of Fig. 1, may be used to connect or disconnect an increment of load, that is, one to three ballasts. In such cases the converter is on continuously. An optional switching method is full load switching. This is accomplished at the d-c input to the inverter, Fig. 2. The entire inverter and load are switched by the d-c contactor, M1. Switch SW2 is the pilot switch for the d-c contactor coil M. An on-off push button station may be substituted for SW2.

The two-lamp, 40-watt, 1500-cycle ballast is smaller in size, considerably reduced in weight, and has one-fourth the losses of a conventional 60-cycle, two-lamp, 40-watt series ballast. Only ballasts specifically designed to operate with the converter can be used in the system. At the present time, any commercially available fluorescent lamp can be operated on the system in combination with a suitable ballast. The greatest advantages in size, weight and loss reductions are obtained by using the newer highly loaded lamps.

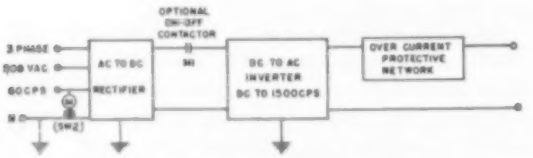

Figure 2. Converter block diagram.

Fig. 2 shows a block diagram of the converter. Fig. 2 is an expanded block diagram of only the second, or converter, block of Fig. 1. Basically, it consists of an a-c to d-c rectifier and a d-c to a-c inverter.

The rectifier section of the present equipment requires a four-wire (grounded neutral), three-phase, 208-volt a-c, 60cycle input. A 90 per cent or better power factor is presented to the input 60-cycle line. A normal three-phase breaker is required as input protection and disconnect. The present 1500-watt unit draws less than five amperes line current at full load. The d-c supply is always on the line when the input breaker is closed. The no load losses are only a few watts. Silicon diodes are used as rectifiers.

A three-phase input was selected because it is commonly available and results in a d-c voltage with only 4 per cent ripple when rectified full wave. Required filtering is small and light. Single-phase inputs are not impossible, but the size and weight penalty for adequate filtering is severe. Future development will probably produce single-phase input units, but the present system is limited to the input described above.

The d-c supply is connected to the inverter through the optional full-load contactor M1. The optional full-load contactor is not used if incremental load switching is desired. Small d-c contactors compatible with the system are available and work satisfactorily. The phase to neutral on-off circuit and the contactor are mounted internally as integral parts of the converter. The only external wiring required is the wire run to switch SW2, Figs. 1 and 2.

The d-c to a-c inverter is essentially a power oscillator and uses transistors rather than the more conventional vacuum tubes. Many different types of circuits are possible for the inverter. Since motor generators have power conversion efficiencies of 75 to 85 per cent, it is mandatory that any static inverter circuit have an equal or higher efficiency. The theoretical maximum efficiency of a class A amplifier is 50 per cent and a class B, 78 per cent. Class A is obviously omitted, and class B could just barely compete if the maximum efficiency were attainable in practice. The future of static inverters did not look very promising until a new mode of transistor operation became known in late 1954.[6,8]

The switching or class D mode of operation has a theoretical maximum efficiency very close to 100 per cent, and such efficiency is fairly easy to achieve in practice. The switching mode of operation is the only one which holds promise of competitive efficiency.

Royer developed one of the earliest circuits to

apply the switching technique.[7] Application of his basic circuit, Fig. 3, to static inverters for fluorescent lighting disclosed three major disadvantages. They are:

(1) The feedback signal used for base drive is obtained from the output transformer. The output transformer must saturate to obtain the drive signal. The output transformer is also expensive and relatively large, since it transforms the entire power output and is square hysteresis loop magnetic material. At higher frequencies, its losses will be a factor in efficiency.

(2) The collector-emitter voltage of the blocking or off transistor is twice the d-c input voltage. The transistor must be operated at less than one-half its rated collector-emitter voltage, thus limiting the power handling capability to less than 50 per cent of its rated value. This disadvantage is basic to all push-pull type amplifiers.

The voltage on the blocking or non-conducting transistor is twice the d-c input voltage because the transformer winding develops a voltage that adds to the d-c supply. The conducting transistor forces all the d-c supply voltage to appear across the transformer winding since the transistor voltage drop during conduction is very low.

(3) The d-c voltage required is so low that a step-down transformer is required if the voltage is rectified from a common 60-cycle distribution voltage. Any such transformer would represent a considerable percentage of the bulk and weight of the total equipment, since it transforms the total input power at 60-cycles.

Since any transistorized converter must compete with rotary operating equipment on a cost per kilowatt basis, it is clear that the transistors must operate as closely as possible to their full rated voltage and wattage. Therefore, the three basic objections must be overcome to make such a power supply commercially practical.

Disadvantages one and two were solved by development of a bridge type oscillator circuit, shown in Fig. 4. Since the transistors operate as switches, a simple equivalent circuit is one which substitutes a double pole, double throw switch for the transistors. A true square wave output voltage is developed without any output transformer. Each transistor can now be operated at any voltage up to its maximum collector-emitter rating. The input d-c is thus at a maximum value. The major disadvantages are that the output voltage, limited by the collector rating, is rather low to supply the input to a ballast, and the 60-cycle transformer is still required on the input.

The obvious answer is to use a transistor of highest obtainable collector voltage. Values of 150 and

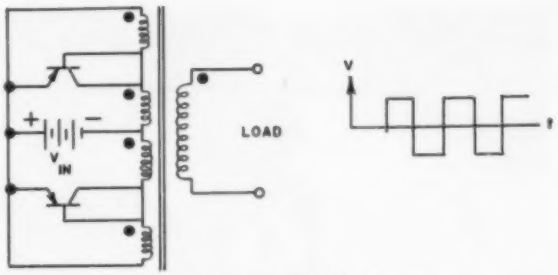

Figure 3. Royer Bright Circuit.

300 volts would be very good, since these are d-c voltages obtained by rectification of 115-volt a-c and 208-volt a-c three-phase inputs. Unfortunately, such power transistor voltage ratings are not commercially available, and present units with a maximum of 60 to 100 volts must be used.

The next best answer is to operate such units in series. Such operation has proved successful to date. Operating five in series allows use of the 300-volt d-c source mentioned above, and each transistor supports 60 volts, 75 per cent of its maximum allowable voltage. The output or load voltage is now 600 volts peak to peak square wave. The input transformer has been eliminated.

A total of twenty transistors is required, and output can be as high as 3.9 kva with available transistors. The efficiency of the device was not as high as expected. The theoretical low wattage loss per transistor was exceeded, so transistor dissipation was examined in detail. The transistor losses are composed of three major parts: the blocking less, the conduction loss and the switching loss.

The blocking loss or off loss is the VI product in the "off" state, a high V and low I yielding a low wattage. The conduction loss is actually I^2R loss when in the "on" or saturated state. Since R is in the order of .05 ohms, the loss can be as high as 5

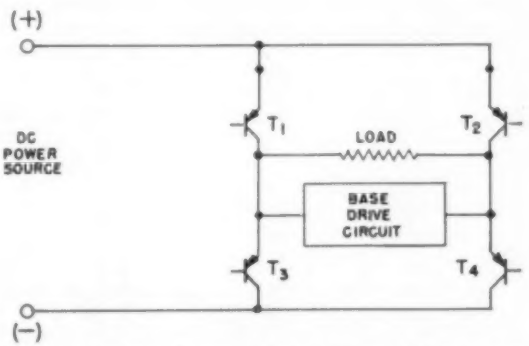

Figure 4. Bridge inverter circuit. T1 and T4 are on at the same time, while T2 and T3 are off. When T2 and T3 are on, T1 and T4 are off.

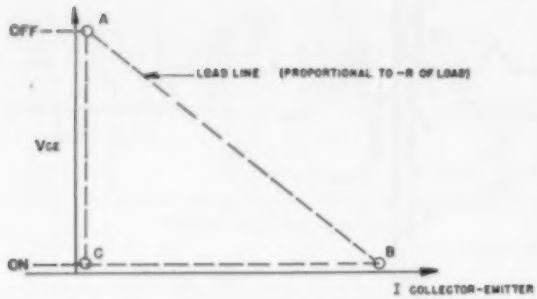

Figure 5. Transistor VI characteristic.

to 10 watts per transistor. The switching loss occurs every time the transistor switches. Little can be done to decrease the off or on losses, but the switching losses can be decreased or eliminated.

Fig. 5 shows the normal switching characteristic of a transistor in common emitter connection. Normal switching follows the load line proportional to (−R) from A to B and back. The area under the load line AB is proportional to the power dissipated during switching.

If the load current can be reduced to zero at or close to the time when transistor switching takes place ,then the load line approaches being parallel to the voltage axis; that is, the load is essentially very high impedance. The transition from off to on and on to off takes place along path A to C and C to A. After point C is reached, the current will increase from C to B and then decrease to C again before the switch to off at A, if the load impedance changes magnitude with time.

The problem is to make the load impedance essentially a cosine function. A series resonant LC network in series with the load R has the required cosine impedance variation and results in sine wave load current. Enough transistor switching losses are eliminated to raise the power conversion efficiency to approximately 94 per cent at full load and 92 per cent at half load. However, the load rms voltage is reduced, thus lowering the rated wattage output. The bridge inverter with filtering must be rated 3000 watts at a load voltage of 210-volt a-c rms.

The large power output of the bridge circuit does not seem consistent with some of the desirable features mentioned earlier. Three kilowatts of lighting is rather large for the average room, and the 20-transistor unit would be physically larger than desirable. A smaller converter circuit, which is essentially half of a bridge circuit, was developed. It is called the "ell" circuit.

Fig. 6a shows the "ell" circuit. The output, Fig. 6b, is actually a pulsed d-c. This can be visualized by substituting a single-pole, double-throw switch for the two groups of transistors. The transistors in series with the d-c supply make the upper output terminal +300 volts when they conduct. When they block, the d-c supply is separated from the load by the high impedance of the collector-emitter circuit. Energy storage is required in the load to develop an a-c voltage across the load R. The capacitor in the LC series filter charges when the output terminal goes to +300 volts d-c as the load conducts one-half cycle of sine wave current. The shunt transistors go on, shorting across the RLC load, when the power supply is disconnected by the series transistors going off. The C discharges through the shunting or shorting transistors and through load R completing the a-c load current.

The efficiency of the "ell" circuit is exactly the same as the efficiency of the bridge. It delivers 1500 watts (half that of the bridge) into the load at a load voltage of 105-volt a-c rms. It uses half the transistors of the bridge, but utilizes them just as economically on a dollar per kw power handling

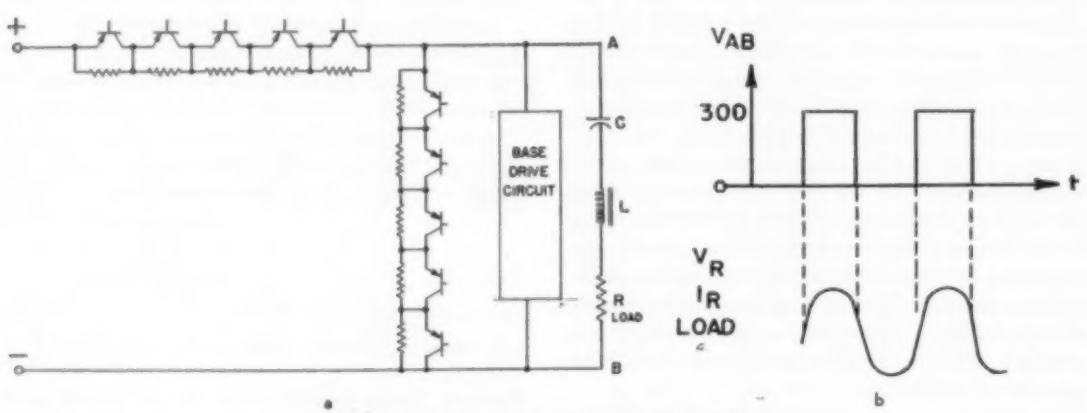

Figure 6. (left) "ell" type inverter, (right) output wave shapes for "ell" type inverter.

Figure 7. Prototype transistorized high frequency converters of the "ell" type circuit shown operating conventional 4-foot rapid start luminaires in this office installation.

comparison. The prototype models shown operating the luminaires in Fig. 7 are "ell" type units.

Both the bridge and "ell" type circuits eliminate the three basic faults of the Royer circuit. These circuits require the lowest number of components of any power oscillator of comparable power output utilizing commercially available components, hence, have greatest promise for lowest cost. In addition, the circuits are ideally suited to high-voltage transistors which will probably be available soon.

The converter requires a resistive load for highest efficiency. Any ballast circuit that reduces to an equivalent resistance at its input terminals will suffice. The series LC filter must be used to have required sine wave voltage input.

A transformer is used to provide correct starting and filament voltages. Both lamps are reactively current limited, one inductively, the other capacitively. Both lamp currents are very close to sine wave. The circuit, Fig. 8, is similar to the 60-cps lead-lag ballast except for the series LC filter and lack of an inductor in series with capacitor ballast. The components, magnetic and capacitive, are very greatly reduced in size.

The favorable response of lamps to high frequency excitation, the very low wattage loss in the ballast, and the very high efficiency of the converter, result in a considerably increased overall circuit efficiency. In the case of the 40-watt rapid-start lamp, the overall luminous efficiency for 60-cycle operation is approximately 54 lumens per watt. The same lamps operated at 1500 cycles result in an overall luminous efficiency of about 63 lumens per watt. This increase in overall efficiency of 15 per cent for 1500-cycle operation as compared to 60-cycle is made up of a 7 per cent reduction in wattage and 8 per cent increase in lumen output.

Any transistor is extremely sensitive to over-current conditions. The junction will melt and the transistor will destroy itself as a result of any (I^2R) (time) product, (watt-seconds or energy), that exceeds the thermal capacity of the device. A fuse will not blow fast enough to reliably protect a transistor. Therefore, a semi-conductor protective network is included in the present equipment which senses over-current conditions and stops the inverter from oscillating. The unit is completely self-protected from high current faults in the load, on the distribution line or internally.

The overall converter losses are less than 100 watts. Sufficient heat dissipation is provided to keep temperature rise down to approximately 30C so that operation in maximum permissible ambient of 40C does not result in transistor temperatures close to the 95C maximum.

The lifetime of a transistor has not been defined to date. Converter life will most probably be determined by the insulation of its magnetic components, capacitors and resistors. Such lifetimes are well-defined and controllable, to some degree. The converter should be maintenance free during its life.

The features of this new high-frequency lighting system are static operation of converter, compact

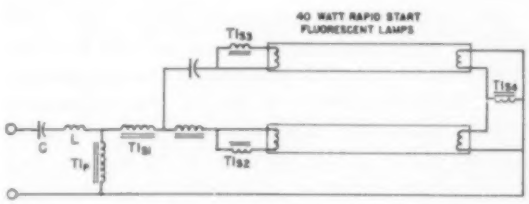

Figure 8. High frequency lead-lag 40-watt rapid start ballast.

physical and electrical size, high efficiency of power conversion, and future potential and flexibility.

Static Operation

The transistorized power source, being completely static in operation, eliminates the need for isolated, sound-proofed, space-consuming installation rooms now required by conventional converters, due to their noise and vibration problems. It is essentially maintenance free and completely self-protected for maximum reliability and long life.

Compact Size

Small physical size, approximately 0.3 cubic feet and 11 pounds, permits simple convenient mounting close to connected lighting load. The installation proximity to load and 1500-watt electrical size minimizes length of high frequency wiring runs and transmission line losses. In addition, the small electrical size permits individual loading of converters and building block method of high-frequency lighting installation, thereby eliminating the complex, costly, paralleling circuitry required by larger power converters in order to operate economically under various load conditions. Smaller converter size also considerably reduces owner investment in stand-by equipment.

Converter Efficiency

The high efficiency of power conversion results in reduced power requirements of the complete lighting system rather than merely making the lamp and ballast combination more efficient and then losing this power saving by poor converter efficiency. Maintaining this efficiency over a wide load range results in maximum circuit flexibility without sacrificing system power economy.

Future Possibilities

The future of the static frequency converter looks very promising. As field experience accumulates, the present devices may be increased in rating. Improvements in present components may also allow increased ratings. Designs will probably be expanded to allow inputs from all the usual commercial and industrial voltage distribution systems.

The cost of semi-conductor devices has been steadily decreasing and forecasts indicate that the trend can be expected to continue. Silicon transistors will be available in the future. Their increased voltage rating will reduce the number required for a given input voltage, thus reducing the size and weight of the converter. Additional size and weight reduction will be possible because of the high junction temperature permissible. Heat sink sizes will be reduced and permissible ambient temperatures increased.

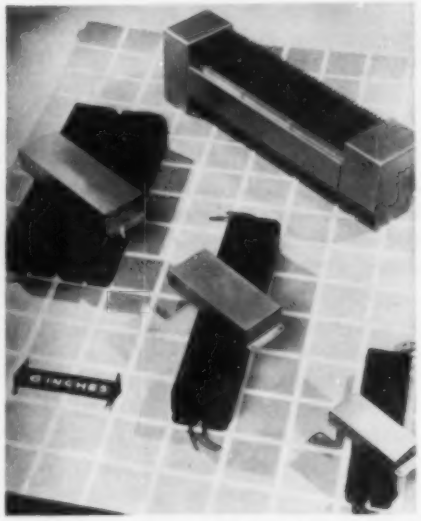

Figure 9. 1½ kw transistorized high frequency converter shown at top of picture. Standard 60-cycle ballast cans in black compared to 1500-cycle ballast size in light color. From left to right: 2-lamp, 8-foot, 1500 ma ballast; 2-lamp, 8-foot, 800 ma ballast; 2-lamp, 4-foot, 430 ma ballast.

A whole new family of semi-conductor devices has been announced. They promise to give performance superior to the transistor at a lower cost. They are essentially transistor diodes. One device is a diode which displays normal diode characteristics except that reverse voltages in excess of its rating will send it into a high conduction in the reverse direction. When circuit current goes to or through zero, the device recovers and displays high reverse impedance. It is essentially a voltage sensitive switch.

A second device is the semi-conductor equivalent of a thyratron. It is a three-terminal device featuring very high gain. It can be driven into conduction, but can only return to non-conduction when current reduces to zero. Both of the devices may find extensive use in high-power oscillators.

The industry trend to higher output fluorescent lamps is well established and apparently will continue. The static frequency converter displays its greatest advantages when used with more heavily loaded lamps (Fig. 9). Large area, multiple-lamp luminaires are becoming more common and require enough power to make attractive the mounting of one static frequency converter per luminaire. Fluorescent street lights and industrial applications are typical examples.

Mercury lamps exhibit little, if any, benefit from high-frequency excitation. Therefore, any advan-

tages in application of high-frequency power must result from decreased losses, size, weight, and cost of ballasting. It appears that the greatest contribution of high-frequency application in the mercury field will be a small, low-loss ballast for mounting directly in the mercury luminaire. Such techniques may also extend the use of mercury lamps for commercial interior lighting.

Acknowledgments

The authors gratefully acknowledge the valuable contributions of Messrs. A. Relation, R. Putkovich, C. F. Scholz, T. N. Humphreville and M. Tomko to the work reported herein.

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DISCUSSION

J. H. CAMPBELL AND Q. D. DOBRAS:* We feel that the authors have presented a very excellent and interesting technical paper describing their work and progress with semiconductors for frequency conversion. The additional advantages of a reliable commercially available power supply using semi-conductors will undoubtedly expand application of high frequency lighting. Recent advances in present static and rotary equipment have made high frequency fluorescent lighting attractive for connected loads of 50 kw or greater, and many large installations are now in use with 420- or 840-cycle power. These systems have demonstrated the general advantages of high frequency operation described in this paper.

With the past record of our interest and work in high frequency fluorescent lighting, it is quite natural that our circuit investigations included the use of semi-conductors for frequency conversion. From these investigations we can support the majority of the information presented in this paper, and also share the authors' optimism with regard to future developments of semi-conductor devices.

We are not certain that an optimum system is necessarily a frequency converter and ballast physically and electrically small enough to supply the lamps in one luminaire. While in some instances this may be desirable, there will be many applications where it will be good practice to use a centrally located panel to supply a single branch circuit, an entire floor or an entire building locating only the ballasts in the fixtures. Power supplies in all instances could be tailored to match any installation requirement by choosing size, voltage, frequency and location for best over-all economics.

The authors mentioned that a protective network is provided to sense over current conditions in order to protect the unit from high current faults in the load and on the distribution line, or internally. Our work has indicated that a current sensing device in a circuit, such as that of Fig. 6, does not afford 100 per cent protection. If one of the series transistors fails normally or by means of a voltage transient, a short generally occurs from emitter to collector. The failure of one transistor does not increase current appreciably, but voltage across the remaining transistors may be over their rating causing failure of all. What has been the authors' experience in this regard?

We agree that an ideal frequency converter should operate from any commonly available system. However, our investigation, like the authors', indicates that at the present time, to obtain lowest cost and highest efficiency, we are limited to three-phase operation.

We fully agree that the future of static frequency converters using semi-conductors appears very promising. Whether such devices will become economically sound depends largely on the progress made in developing semi-conductors capable of operation at higher primary voltages. It is anticipated that semi-conductor frequency converters will be available at a competitive price with present high frequency power systems and therefore provide greater over-all economy for fluorescent lighting.

G. A. MEYERS:* The introduction and use of lamps having higher loadings — up to 25 watts per foot or more — imposes penalties in ballast size, weight, noise and heat. Operating such lamps, indeed, any lamps, at high frequency yields gratifying improvements in lamp performance and the virtual elimination of the ballast as a problem. This leaves the frequency converter as the key device on which the success of the system frequently depends.

The authors are to be congratulated on the engineering and development of the system described in their paper. Of the several methods of frequency conversion now in use, I believe the semi-conductor switch type of device will ultimately be the one, perhaps the only one, in most general use, because of the several advantages the authors have outlined. It should be particularly applicable to very high output lamps which require some degree of cathode heat for best performance.

Like many new developments, however, this one is largely dependent on parallel developments in other fields, such as semi-conductor technology. It is to be hoped that these will be forthcoming so that this system can be commercially available and competitive.

Could the authors give us some idea of the present cost per kw of their system and what they feel will be the ultimate costs, assuming the use of semi-conductor devices of the more desirable type? Is there any reason for choosing 1500 cycles? Couldn't further gains be made at frequencies at which powdered-iron core inductors are practical, for example? At what current and wattage are the 40-watt rapid-start lamps operated?

*General Electric Co., Lamp Division, Cleveland, Ohio.

*Sylvania Electric Products Inc., Danvers, Mass.

It seems likely that this paper will be the first of many we shall see describing the use of semi-conductor devices in the operation of fluorescent lamps.

W. H. JOHNSON, J. L. WINPISINGER, AND J. F. ROESEL, JR.:* The authors wish to emphasize that our semi-conductor power supply has already demonstrated a high degree of reliability. Life testing in the installation shown in Fig. 7 has not produced a single power supply failure to date. We believe that the very long life expectancy of the semi-conductors will be realized.

Location of a frequency converter external and remote from a luminaire will always impose frequency limitations on the power converter source. Power losses in a power distribution line at frequencies in excess of 1500 cycles per second are not tolerable. In order to minimize the efficiency of a given converter, ballast and lamp combination, the designer must be free to choose a frequency without distribution system limitations. The only way to do this is to eliminate the distribution line, make the power converter part of the lamp ballast and locate it adjacent to the lamps. The distribution to luminaires is then entirely 60-cycle, and normal industrial and commercial practice can be employed for primary protection.

The overcurrent protective device is strictly an output overcurrent protection and serves the same function as a fuse. It protects the converter from high currents at its output terminals due to partial load shorts or line-to-line shorts. All such fault currents are conducted by transistors and would be destructive if allowed to continue until the watt-second or I^2R product elevated the junction temperature to the melting point. The protective device simply stops the power converter from oscillating before such temperatures are reached. In this respect, it provides "100 per cent protection."

The preceding reduces to the fact that the overcurrent protection will not allow one transistor of a series string to fail thermally because of overcurrents. As the discussers point out, failure of one transistor in a series string does occur, resulting in a collector-to-emitter short and a slight increase in current. The overcurrent network will not, and is not intended to, detect or protect against such insignificant current increases.

It is useless to attempt to protect against such failures with overcurrent detecting devices, since the failures are not caused by overcurrent conditions. The slight current increase is the *result* of transistor failure, not the cause. The real cause of such failures is unequal voltage division between the series transistors. One transistor exposed to a voltage higher than its maximum tolerable collector-base or collector-emitter voltage will immediately short collector-to-emitter and cause the entire voltage to be supported by one less than the normal number of transistors. The result is a cascade failure of the entire series string.

The obvious cure is to insure equal voltage division between transistors. This is necessary only during the blocking, or "off," and switching parts of the cycle. During "off" state, the resistors across the emitter-collector terminals form a voltage divider. The transistors can see only the proper IR voltage.

The excursion from "one" to "off" and vice-versa may not take place at the same speed for all units in series. The result is a momentary change in voltage distribution during the excursion which may create a spike of destructive magnitude on the leading or trailing edge of the voltage waveshape. The transistors must be voltage-matched during the switching time. The authors have created techniques which insure such voltage matching.

The authors feel that the cost of this new frequency converter can eventually be competitive with any other form of conversion being used at present.

In answer to Mr. Meyers' question, the lamps in the prototype circuit of Fig. 7 are operating at 40 watts.

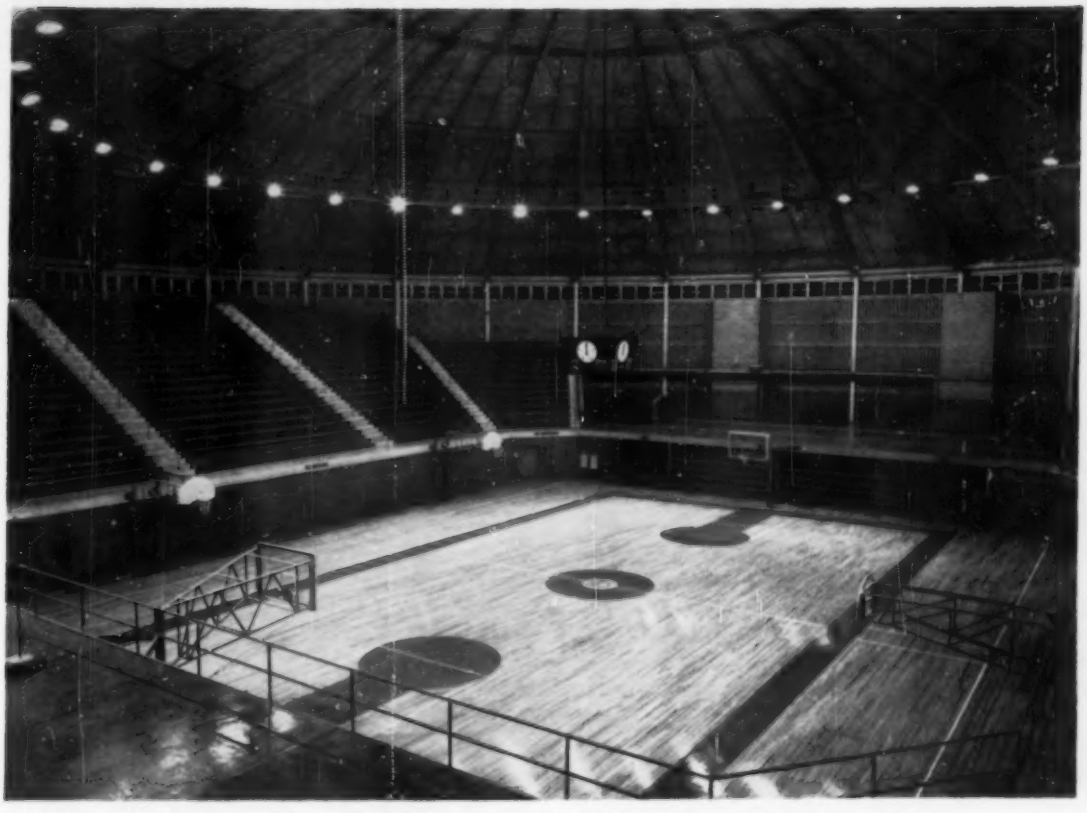
The authors and the discussers express a common conviction that higher voltage semi-conductors will soon be available. It is significant that during the time between writing and presenting the paper, announcement was made of the availability of 300-volt silicon transistors. We are sure that many other new developments will soon follow.

*Authors.

What is a lm/ft²? Cause for "Errata"

When is a lumen per square foot not a footcandle? In the residence lighting field, of course. Much to IE's chagrin, "average lumens per square foot" values were mistakenly converted into "footcandles" in the report on the prize-winning MMILJ entry of Miss Elizabeth Meehan, in November 1958 IE.

Apologies to Miss Meehan and to readers who should re-translate general illumination values to average lumens per square foot.



INSTALLATION AT CAPITOL HILL HIGH SCHOOL, OKLAHOMA CITY, OKLA.

Floodlighting a Field House

LIGHTING OBJECTIVE: To provide illumination, with a minimum of glare, for a variety of sports in a high school field house, and at the same time provide for easy maintenance of equipment.

GENERAL INFORMATION: This field house is an example of a modern high school's multi-sport area. Basketball, the principal athletic activity, is played on the main floor with other courts available for volleyball and shuffleboard on the second floor. The field house is circular in construction with a diameter of 200 feet. The ceiling is dome-shaped with a height of 70 feet at the center over the main floor.

INSTALLATION: As shown above, a catwalk, suspended from the domed ceiling, and encircling the basketball court, provides the mounting location for the floodlighting equipment. The catwalk is 50 feet above the basketball floor and 40 feet above the volleyball and shuffleboard courts.

(over)

A.I.A. File No. 31

Thirty-two Westinghouse VRC-18WP, enclosed, Type 5 floodlights with 1500-watt incandescent lamps (mounting height, 50 feet) provide an initial measured illumination level of 70 footcandles for basketball play.

Sixteen Westinghouse VEA-14, open, Type 6 floodlights with 500-watt incandescent lamps (mounting height, 40 feet) provide an initial measured illumination level of 30 footcandles for volleyball and shuffleboard play.

Fourteen Westinghouse VEA-14 floodlights, as above, (mounting height, 28 feet, average) provide an initial measured illumination level of 12 footcandles on the bleachers.

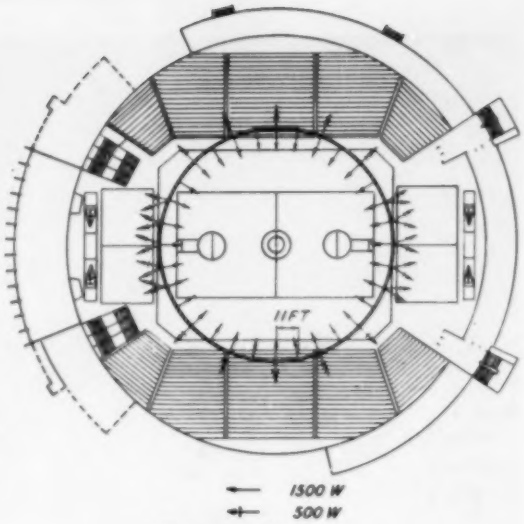


Figure 2. Plan view.

Lighting designed by Coston, Frankfort, and Short. Architect: Harold Short; Engineer: Frank B. Creekmore; Electrical Contractor: Shaver and Son, Oklahoma City, Okla.

Lighting data submitted by A. T. Fisher of the Westinghouse Electric Corp., Tulsa, Okla., as an illustration of good lighting practice and to aid in the design of similar installations.

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Highway Lighting Without Glare—A New Lighting Technique

By W. M. WALDBAUER

Introduction

The last several years have seen a tremendous growth in the number of vehicles utilizing highways in this country. Traffic-conscious city, state and federal governments have realized that they must expand their roadways both in capacity and in mileage in order to handle the ever increasing traffic flow. The increase in long distance pleasure travel by the American public has substantially promoted the growth of freeways, limited access highways and turnpikes of the multi-lane, dual-roadway type. There is general agreement that eventually these highways should be lighted for maximum safety.

With wider and wider medial strips, these roadways must be considered separately, from a lighting standpoint. For example, all new roadways built in cooperation with the Federal Highway Program must have medial strips at least 32 feet wide. Heretofore, it has been the practice to provide standard type street lighting systems only in interchanges and service areas and the deceleration and the acceleration lanes leading to and from these areas on the modern turnpike type roadways. This practice has generally been satisfactory in guiding the motorist to and from these areas and providing advance warning of traffic merging areas. However, such systems are of no value in assisting the motorist to discern traffic and obstacle hazards along the highway between these areas. As a result, it has been necessary for the motorist to depend entirely on the automotive headlights with which his vehicle is equipped to provide the necessary illumination. Present day vehicle speeds and recognition distances provided by commercially available automotive headlight systems do not always allow the average motorist sufficient time to execute the necessary safety or precautionary maneuvers. Assuming that a vehicle is equipped with good brakes, and allowing a ¾-second driver reaction time (fairly alert driver), a vehicle speed of 60 miles an hour would require a minimum of 260 feet to stop on dry concrete. However, if we assume a two-second reaction time and a 0.4 coefficient of friction, driver stopping distances for 60 miles per hour would be 480 feet and for 70 miles per hour, 610 feet. Actual tests showed that the values of stopping distances given above may be substantially lower than those found in actual practice, due to the many variations of different vehicles, drivers, and pavement conditions.[2] When we realize that present day automotive systems provide 0.1 to 0.2 footcandle on a vertical surface 750 feet in front of the car, it is easily understood how a motorist can fail to recognize an obstacle in time to take the necessary corrective action.

For the purpose of this paper, we shall define a highway as a multi-lane, dual-roadway type. Specifically, we have chosen roadways 36 feet wide with a 32-foot medial strip separating the two roadways. A 36-foot width, therefore, provides for two high-speed traffic lanes plus an emergency lane located on the right hand side of paved traffic lanes.

Major Types of Systems

General

Whenever the lighting industry has been faced with a new application for street lighting, the natural tendency has been to extend the use of presently available luminaires, with little or no modifications, to the optical principles involved. It is not surprising, therefore, that until recently, intra-city expressways, turnpike interchanges, and access roads, and now even the Connecticut Turnpike have utilized standard bi-directional street lighting luminaires to provide the necessary illumination. The use of such luminaires is based largely on the facts that they are commercially available, and a great deal of application experience is available.

The Federal Bureau of Roads suggests that lighting arrangements and illumination values shall be in accordance with current provisions of the *American Standard Practice for Street and Highway Lighting*. In general, this would require a minimum average maintained illumination level of 0.8

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.
AUTHOR: Lighting Division, Westinghouse Electric Corp., Cleveland, Ohio.
This paper accepted by the Papers Committee of I.E.S. as a Transaction of the Illuminating Engineering Society.

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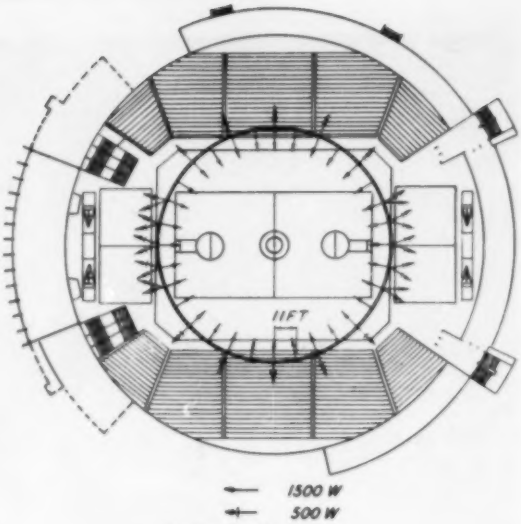

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By W. M. WALDBAUER

Introduction

The last several years have seen a tremendous growth in the number of vehicles utilizing highways in this country. Traffic-conscious city, state and federal governments have realized that they must expand their roadways both in capacity and in mileage in order to handle the ever increasing traffic flow. The increase in long distance pleasure travel by the American public has substantially promoted the growth of freeways, limited access highways and turnpikes of the multi-lane, dual-roadway type. There is general agreement that eventually these highways should be lighted for maximum safety.

With wider and wider medial strips, these roadways must be considered separately, from a lighting standpoint. For example, all new roadways built in cooperation with the Federal Highway Program must have medial strips at least 32 feet wide. Heretofore, it has been the practice to provide standard type street lighting systems only in interchanges and service areas and the deceleration and the acceleration lanes leading to and from these areas on the modern turnpike type roadways. This practice has generally been satisfactory in guiding the motorist to and from these areas and providing advance warning of traffic merging areas. However, such systems are of no value in assisting the motorist to discern traffic and obstacle hazards along the highway between these areas. As a result, it has been necessary for the motorist to depend entirely on the automotive headlights with which his vehicle is equipped to provide the necessary illumination. Present day vehicle speeds and recognition distances provided by commercially available automotive headlight systems do not always allow the average motorist sufficient time to execute the necessary safety or precautionary maneuvers. Assuming that a vehicle is equipped with good brakes, and allowing a ¾-second driver reaction time (fairly alert driver), a vehicle speed of 60 miles an hour would require a minimum of 260 feet to stop on dry concrete. However, if we assume a two-second reaction time and a 0.4 coefficient of friction, driver stopping distances for 60 miles per hour would be 480 feet and for 70 miles per hour, 610 feet. Actual tests showed that the values of stopping distances given above may be substantially lower than those found in actual practice, due to the many variations of different vehicles, drivers, and pavement conditions.[2] When we realize that present day automotive systems provide 0.1 to 0.2 footcandle on a vertical surface 750 feet in front of the car, it is easily understood how a motorist can fail to recognize an obstacle in time to take the necessary corrective action.

For the purpose of this paper, we shall define a highway as a multi-lane, dual-roadway type. Specifically, we have chosen roadways 36 feet wide with a 32-foot medial strip separating the two roadways. A 36-foot width, therefore, provides for two high-speed traffic lanes plus an emergency lane located on the right hand side of paved traffic lanes.

Major Types of Systems

General

Whenever the lighting industry has been faced with a new application for street lighting, the natural tendency has been to extend the use of presently available luminaires, with little or no modifications, to the optical principles involved. It is not surprising, therefore, that until recently, intra-city expressways, turnpike interchanges, and access roads, and now even the Connecticut Turnpike have utilized standard bi-directional street lighting luminaires to provide the necessary illumination. The use of such luminaires is based largely on the facts that they are commercially available, and a great deal of application experience is available.

The Federal Bureau of Roads suggests that lighting arrangements and illumination values shall be in accordance with current provisions of the *American Standard Practice for Street and Highway Lighting*. In general, this would require a minimum average maintained illumination level of 0.8

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footcandle, while maintaining a 4:1 average to minimum ratio. Using modern day, high efficiency, mercury luminaires, this would allow spacings in the order of 200 feet maximum.

For the most part, application experience using these bi-directional luminaires has been limited to urban areas. Under these condition , the motorist is driving at relatively low speeds for short periods of time. Even in the more recent application of these luminaires to intra-city expressways, the amount of time that a motorist spends driving under such a system is relatively short. If we then further extend the application of these luminaires to lighting many miles of turnpike or limited access roadways, we are faced with an entirely different situation. As the car travels along a roadway so illuminated, there is a pronounced blink each time the windshield cuts off the light from the approaching luminaire. At normal turnpike speeds, this blinking, or so-called shutter effect, would occur at the rate of 24 to 30 times per minute. Where there is no specific data covering this situation, many people have expressed concern that this pronounced blinking effect, rapidly repeated, will produce a state of mild hypnosis in the driver which, in turn, would decrease his alertness and most probably increase his reaction time. Such opinions are, of course, highly speculative, since no systems are presently available under which this effect could be evaluated. The continuous lighting of the Connecticut Turnpike may provide some of the answers regarding this particular point.

More recently, it has been proposed that a unidirectional lighting system be used on the dual type highway. For many years, there has been considerable discussion regarding just how the human eye actually sees. Certainly, under a standard bidirectional system, this seeing is provided by illumination which allows both direct discernment and silhouette discernment of the obstacle ahead. A unidirectional system, which would aim its lights against traffic, has been proposed on the basis that normal seeing at low illumination levels is primarily by silhouette. Certainly small dark objects are seen primarily by their silhouette against a brighter background, which in this case would be the brightness of the pavement itself. However, it is felt that the eye discerns most larger objects by direct discernment and certainly cars along the roadways are seen as cars, not just as silhouettes.

It is felt that one of the major limitations of these systems would be the fact that they could not be sepaced over long distances. In order to maintain an adequate footcandle level on the roadway and the resultant pavement brightness, high candlepowers would be necessary if these luminaires were extended beyond 150 to 200 feet apart. It is obvious that such an "up stream" lighting system cannot eliminate the luminaire as a potential glare source.

A third system, and the one with which this paper deals directly, is a highway lighting system, uni-directional in nature, aimed so that the light is in the direction of traffic flow. This system, together with the associated photometric requirements, luminaire requirements and application requirements will be discussed more fully in this paper. For now, it suffices to say that these luminaires would be installed on the left hand side of the roadway, that is, in the medial strip, aimed in the direction of traffic flow, with little or no light coming back toward the driver.

A fourth possible system for highway lighting would be the use of continuous fluorescent strip mounted off to one side of the roadway. This would, in essence, provide the greatest amount of light directly across the highway and, if the mounting heights were properly chosen, could provide good illumination. Based on the recent fog study at the Pennsylvania State University, such a lighting system may provide improved visibility under fog conditions. However, it is felt that the cost, at least at this time, would be such that it could not be considered for lighting the many thousands of miles of open highway.

Disability Veiling Brightness Comparison

Disability veiling brightness of disability glare is related to the total amount of light flux that enters the eye and the angular displacement of the glare sources from the normal line of sight. In this paper, the expressions developed by Holladay and Stiles,[3] as modified by Moon and Spencer,[4] have been utilized to calculate the disability veiling brightness for various systems. The standard formula for calculating DVB is as follows:

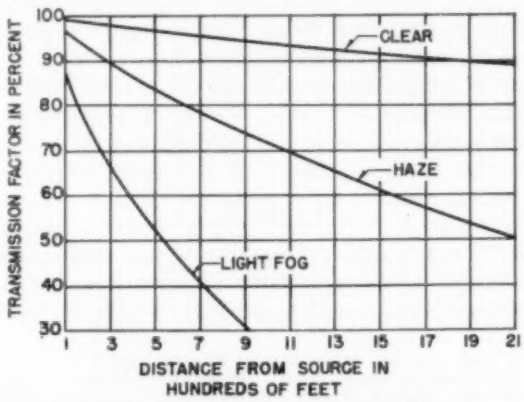

Figure 1. Atmospheric transmission factor.

$$DVB = \frac{10 \pi E v}{\theta^2}$$

where Ev = The vertical footcandle at the eye, on a plane perpendicular to the normal line of sight, and

θ = The angle between the normal line of sight and the glare source measured in degrees.

This expression has been further modified to take into account the atmospheric absorption. The resultant expression then may be expressed as follows:

$$DVB = \frac{10 \pi E v}{\theta^2} \cdot T^x$$

where T = The transmission factor for various atmospheric conditions per 100 feet, and

x = Distance from the glare source to the eye in hundreds of feet.

Fig. 1 shows the effect of atmospheric transmission under various conditions.

Referring now to Fig. 2, System 1 represents a typical bi-directional installation on a divided highway with 36-foot roadways and a 32-foot medial strip based on the luminaires being spaced 200 feet apart. The observer is located 10 feet in from the edge of the roadway and 100 feet from the first luminaire.

In calculating the disability brightness for a conventional bi-directional system, two types of systems have been utilized. The first is in idealized system which is represented by a luminaire having positive cut-off above 79 degrees vertical in the main beam area and cut-off across the street such that the observer does not receive any flux from luminaires located on the opposite roadways. The results of this calculation are shown on Table I. For the second series of calculations a standard, commercially available luminaire was used. In the design of this standard street lighting luminaire, many factors combined which did not permit the absolute cut-off specified above for the ideal system.

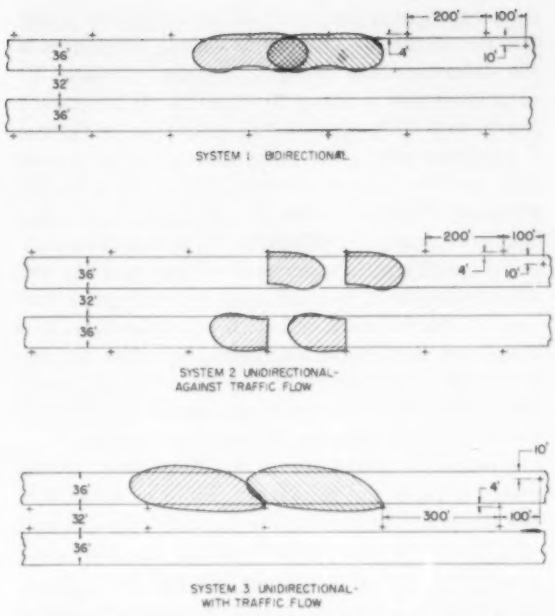

Figure 2. Luminaire arrangement for glare calculations.

TABLE I — Disability Veiling Glare from Idealized Design, Comparison of System DVB.

	System 1		System 2		System 3
	Mercury	1500 ma Fluorescent	Mercury	1500 ma Fluorescent	Mercury
Totals	.0718	.0422	.0718	.0422	0
Loss in Visibility[6]	30.6%	24.7%	30.6%	24.7%	

TABLE II — Disability Veiling Glare from Practical Design, Comparison of System DVB.

Pole No.	System 1		System 2			System 3
	Mercury	1500 ma Fluorescent	Mercury	1500 ma Fluorescent		Mercury
1	.07180	.0422	.07180	.0422	1	——
3	.00890	.0256	.00890	.0256	3	——
5	.00800	.0229	.00800	.0229	5	——
7	.00620	.0226	.00620	.0226	7	——
9	.00628	.0223	.00628	.0223	9	——
11	.00570	.0228	.00570	.0228		
13	.00564	.0214	.00564	.0214		
2	.014000	.0134	——	——	2	.00010
4	.000845	.0020	——	——	4	.00219
6	.000760	.0018	——	——	6	.00511
8	.000595	.00183	——	——	8	.00995
10	.00078	.0024	——	——	10	.01220
12	.000510	.00185	——	——		
14	.000460	.00175	——	——		
Totals	.13047	.20533	.11252	.18030		.02955
Loss in Visibility[6]	38%	44%	36%	42.5%		21.2%

As a result, each luminaire shown in System 1 contributes to the total disability veiling brightness at the observer. The amount of glare produced by each luminaire is shown in Table II. It is interesting to note that while the mercury type of System 1 produces more glare from the closest luminaires than does the fluorescent type, total DVB is less for mercury. This, of course, is primarily due to the fact greater control of light is obtainable from mercury systems with their smaller light sources, and the upper cut-off is much sharper. A typical fluorescent system starts out with less brightness produced by the closest luminaire, but does not decrease at nearly so rapid a rate, with the result that more glare is actually produced by this fluorescent system than by the mercury system.

System 2 represents a uni-directional system aimed towards the driver. It should be noted that the luminaire in this case represents only one-half of a luminaire used under System 1, the side facing away from the driver being blacked out. No attempt has been made to take into account that a greater amount of light flux, and consequently more glare, would be directed towards the driver if the luminaire were designed expressly for this purpose. It is seen that in this system the idealized luminaire (Table I) provides exactly the same amount of glare as did the luminaire in the bi-directional system.

In Table II, a more practical system is calculated on the basis of glare, and it, too, provides essentially the same amount of disability veiling brightness as did System 1, with the exception that the luminaires on the opposite roadway produced no glare component.

System 3 represents a uni-directional system which is aimed in the direction of traffic flow. Here the idealized luminaire (Table I) would be one which would produce a cut-off such that the light from the opposing luminaires would not reach the observer's eyes. Under such an idealized system, no disability glare would be encountered. From a more practical standpoint, luminaires which are lighting the opposite roadway would be visible to the observer and, therefore, would produce a certain amount of disability veiling brightness (Table II). It should be noted that these calculations are based on a distribution having the minimum performance which the author considers acceptable. It is hoped that through further study and greater refinement in design these values will be further decreased.

Here then is a system which, even in its practical state, provides less disability veiling brightness than the idealized version of either the bi-directional system or the uni-directional aimed towards the traffic system. Up until now, the street lighting designers have paid more attention to the illumination which the system would produce than to the comfort of the motorist. Certainly, no one will deny that the most important task of street lighting is to provide visibility. However, when we consider that a motorist may be subjected to long hours of driving under the visibility conditions produced by a lighting system, his comfort becomes a major factor. The author feels that both visibility and comfort must be equally evaluated when considering highway lighting systems.

Possible Criteria for Evaluating A Highway Lighting System

In general, the street lighting industry has long recognized that horizontal footcandles, as a means of evaluating a particular installation, are applicable only when the mounting height and type of distribution are predetermined. For urban areas, this has represented the most convenient way of evaluating a given system. The method has, however, depended largely on prior experience and visual observation of qualified observers for correlating all the factors concerning visibility, glare, uniformity and comfort. If the distribution of the luminaire in question is substantially changed from that on which we have prior experience, it is felt that horizontal footcandles alone will not give the complete story.

It is hoped that the work of Messrs. Blackwell, Fry and Finch will result in a visibility meter which will correlate all of these aforementioned factors, and whose size and manner of operation will be such as to make it practical for use in evaluating street and highway installations.

Development of a Highway Luminaire

General Considerations

In the choice of an actual design approach for a highway luminaire, many factors must be taken into consideration and many compromises made. The theoretical considerations of the way we see and the effects of disability and discomfort glare must, of course, be the basic motivating force behind a good decision. Other factors which must be considered are: cost, accessibility of the luminaire for maintenance, pole spacing, and pole location as a contributing factor in accidents. Due to the fact that highway driving is a continuous process without appreciable environmental change, it is felt that a design which achieves freedom from glare is of major importance. With poles at a uniform spacing and the car traveling at a constant speed, the consistent flashing of a glare source at regular

intervals into the eyes of the driver is believed to be one of the most serious problems in highway lighting.

This premise precludes the choice of a uni-directional system with the light source pointed towards traffic or a standard bi-directional type of luminaire. It also means that the utmost design consideration must be given to making sure the luminaire is not an offending glare source.

Visibility is the second most important factor. Automobiles are equipped with headlights which produce a certain type of visibility. This visibility is the result of vertical footcandles which serve to reveal an obstacle or object to the driver by means of reflected glint and direct discernment. It is strongly believed that a lighting system which depends on another type of visibility for revealing the object, *i.e.*, silhouette discernment, when used in combination with high beam headlights, would produce a lower over-all visibility rating for the combination and would tend to confuse a driver, since his basis of judgment would not be constant. With this as an added factor, the choice of a luminaire which is uni-directional in nature with the maximum candlepower directed in the direction of traffic flow is clearly indicated.

Luminaire Distribution

The factors of physical size, lumens per watt and lamp life led to the selection of the 400-watt E-H1 mercury lamp as the most suitable light source to produce the required vertical footcandle level. It was felt that to facilitate maintenance operations the luminaire should be located off the actual roadway area so that it could be serviced with a truck which would not have to be stopped in an active traffic lane. This indicated that the light distribution should be such that no light would be directed directly downward from the luminaire. The tentative specification of the luminaire mounting location from five to six feet outside the traffic lane was selected.

Working backwards from the criteria of one vertical footcandle, it was possible to construct an idealized candle distribution for the luminaire. This is shown in Fig. 3, and is further discussed as related to the beam requirements.

If such a highly idealized type of distribution could be obtained, we would have a roadway which would be uniformly lighted to the level of one footcandle vertically and with no light into the opposite roadway. However, all will recognize that one cannot design a luminaire which will provide a main beam candlepower in the order of 100,000 and so cut off the beam as to have zero candlepower immediately adjacent to this peak. It is, therefore,

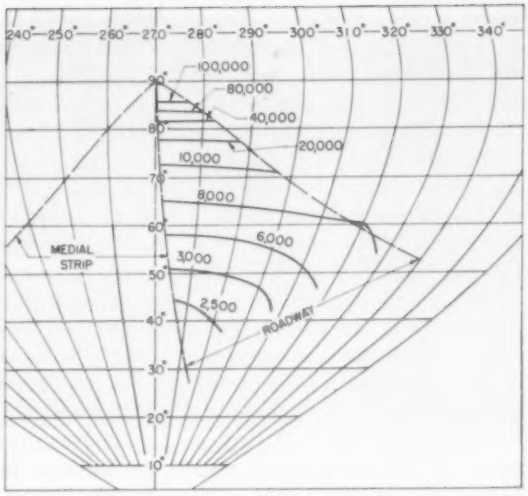

Figure 3. Ideal distribution.

necessary to modify this idealized distribution to one which is more practical, considering the inherent spread of any optical system. Such a distribution is shown in Fig. 4. This distribution still provides essentially uniform vertical footcandles in the order of one footcandle, and the asymmetric distribution requires a very sharp cut-off in the direction of the opposite roadway.

The intial considerations were based on luminaires being spaced approximately 300 feet on the left hand side of the roadway with the poles located in the medial strip. The luminaire would be located four feet to the left of the edge of the high speed lane with the pole located a minimum of ten feet from the edge of this lane. Luminaire mounting

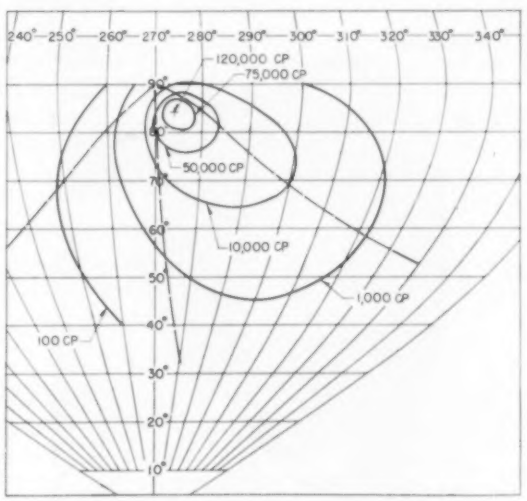

Figure 4. Proposed distribution.

height would be 30 feet. The luminaire would be aimed so that the axis of the parabolic section would intersect the pavement at the middle of the roadway directly opposite the next pole. This would result in an aiming angle of approximately 84 degrees vertical and 274 degrees lateral. Even with a medial strip 32 feet in width, the adjacent curb of the opposite roadway is only 10 degrees laterally from the peak of the main beam. As the highway extends further and further away, both roadways tend to be asymptotic and will converge at 90 degrees vertical and 270 degrees lateral. Such a condition makes the cut-off requirements extremely critical. As can be seen from the proposed distribution, the peak candlepower of 120,000 must be reduced to 10,000 in 7 degrees, to 1,000 candlepower in 10 degrees, and to 100 candlepower in approximately 20 degrees. These distribution requirements are tied in very closely to the DVB calculations made previously. It is only with good lateral control that such low values of disability veiling glare can be achieved.

Optical System

Since lateral control is of the greatest importance, the optical system design was based on achieving minimum lateral spread with all possible accent on sharp cut-off to the left of the main beam peak.

As was mentioned before, the light source used in this luminaire would be a 400-watt E-H1 mercury lamp. The lamp would be mounted in a vertical position with the base up. The main body of the reflector would be a parabolic section of revolution whose major diameter is 20 inches. The rear section of the reflector essentially by-passes light around the arc stream in such a manner as to minimize spread. A prismatic lens would be utilized to further control this light. This prismatic lens would be divided to two major areas, one to deal with the light coming off the parabolic reflector, and the other to deal with direct light from the lamp (see Fig. 5). The center concave section is essentially a bull's-eye segment which will take the divergent direct light and transmit it as a parallel beam. The outer annual convex section of the refractor will modify the essentially parallel light coming off the parabolic section in such a manner as to provide an asymmetric beam of high candlepower whose lateral spread towards the opposite roadway is the bare minimum. Every precaution was taken so that both the main beam rays and the prism riser rays would not provide an offending component into the opposite roadway.

Figure 5. Specially designed luminaire.

Preliminary Evaluation

To prove that good visibility could be obtained from a highway lighting system which depended essentially on vertical footcandles to provide discernment, an experimental installation of three luminaires was made on a test street. The test installation was made utilizing a general purpose floodlight with an E-H1 mercury lamp and a horizontal spread lens. The luminaires were mounted approximately 30 feet above the pavement with a spacing of 250 feet between units. In addition, an open suburban unit with a L-H4 100-watt mercury lamp was mounted adjacent to the general purpose floodlight. The purpose of the low wattage open unit was to evaluate the desirability of a small component of light down and towards the driver. Units were mounted and wired in such a way that they could be operated independently of each other or together, as desired. Since the primary object of this test installation was to test the visibility, no attempt was made to achieve the adjacent lane cut-off.

Figs. 6, 7 and 8 show the results obtained from this test installation. The target shown in the photographs is of the type recommended by Finch[4] in his studies on visibility. The target shape is a three-sided section of a right rectangular prism with one normal and two 45-degree vertical planes, each one foot wide. Two target heights were selected, the first five feet high and the second, one foot high. Targets were painted with an extremely flat paint. The white target had an average reflection of 87 per cent while the black target had an average reflectance of 7½ per cent as measured with a Taylor reflectometer.

Fig. 6 shows the installation with both the general purpose floodlights and the open suburban units on. The white targets are located 200 feet

Figure 6. Test installation with general purpose floodlights and open suburban units turned on.

Figure 7. Test installation with open suburban units turned off.

from the camera while the black targets are located 450 feet from the camera. Fig. 7 shows the same target location but with the open suburban units turned off. Fig. 8 is again with the open suburban turned off, *i.e.*, no light coming back towards the driver, with cars placed as they would be on the emergency lane of a 36-foot roadway. The cars are located 150 feet, 250 feet, 375 feet and 650 feet, respectively, from the camera.

Fig. 9 shows both horizontal and vertical footcandle readings taken of this test installation. These readings were taken with both the general purpose floodlights and the open suburban units on. Since this installation requires cooperative action between the various luminaires, it is felt that the readings taken from the second luminaire on out represent those which would be representative of a continuous installation. It should be noted that in this area the maximum to minimum ratio of vertical footcandles was 1:9. A similar set of readings was taken with the open suburban units off. Little effect on the vertical footcandle level was noted.

It is felt that the above photographs and readings taken on the test installation conclusively prove that the uni-directional lighting system aimed in the direction of traffic flow provides a satisfactory level of illumination with good obstacle discernment and no offending glare. Since this installation was made prior to the time when a luminaire specifically designed for this purpose was available, it was not possible to evaluate the light coming from luminaires lighting the opposite roadway.

Figure 8. Test installation with open suburban units turned off and cars placed as on the emergency lane of a 36-foot roadway.

Conclusions

Throughout this paper the need for evaluating a highway lighting system based on two primary criteria has been stressed. These are that it must provide good visibility while maintaining comfort at the highest practical level. It has been shown that the system outlined in this paper can provide good visibility and obstacle discernment. In addition, it has been shown that with the proposed distribution a system which is virtually free from glare can be achieved.

While it is apparent that complete elimination of veiling glare cannot be expected in the first optical

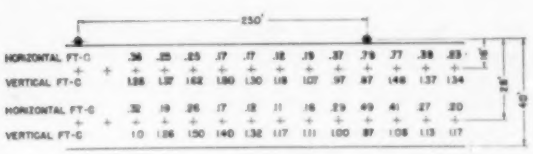

Figure 9. Footcandle readings of test installation.

designs, it does exist as a goal. The minimum acceptable goals which have been set are below, in DVB, the idealized minimum possible with the other two systems. Certainly the end result, highway lighting without glare, is an objective that now appears attainable.

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DISCUSSION

W. H. EDMAN:* Without doubt, this paper will stir up some controversy. There will be many who believe it to be a bit bold in advocating the reversal of light flux direction and literally abandonning the popular concept of silhouette lighting. I, for one, am glad to see this development, because we have gotten a little off balance in advocating, almost exclusively, that roadway lighting should depend on pavement brightness and silhouette seeing.

Let us be truthful and admit that silhouette lighting is "poverty lighting" and is not preferable to seeing by reflected light if the latter can be economically achieved. This approach seems to have much promise. Also, let us not forget that it is much easier to judge depth perception under direct illumination than by silhouette. In fact, on observing the test installation described by the author, I found the difference in depth perception quite remarkable. Judgment of distance too, will become more important with the ever increasing high-speed traffic of the future.

This system is really a continuous or super-vehicular lighting system. It has the added advantage of high mounting. Under such a system, the need for main beam vehicular headlights literally becomes unnecessary. This would also eliminate the headlight glare from oncoming traffic.

Under the severe limitations of the increasingly lower automobile designs, it is unlikely that much greater headlight candlepower will result in any net accomplishment.

D. A. TOENJES:** It is encouraging to see, as evidenced by this paper, the continuing interest in effects of glare from roadway lighting installations. In this proposal of a unidirectional lightng system with overhead mounting, the author recognizes the necessity of modifying an idealized candlepower distribution into the form of a practicable luminaire.

One question on which the author might care to comment is this: In some earlier trials of low-mounted lighting, also aimed uni-directionally with the flow of traffic, one most disturbing glare effect was that of high candlepower into the rear-vision mirrors of each vehicle. In this new system, will the higher mounting remove such reflections of high beam candlepower sufficiently, from the driver's field of vision? We note that the maximum beam candlepower is depressed only six degrees below horizontal. Since it is proposed that the luminaires be mounted on the left-hand side of the road, the reflections into a vehicle's *side* mirror might be the main cause of such glare difficulty.

G. A. NAGEL:* This paper presents an interesting yet controversial approach to the subject of expressway lighting. The system described presents certain refinements over previous installations based on similar principles, but the idea of providing "downstream" directional lighting is not new. It is to be noted that such installations as have been made have not been regarded as successful because the disadvantages have outweighed the advantages.

There is need for some reflected light from obstacles where reverse silhouette, detail and color discrimination are desired. It may be that obstacle brightness is required in locations where the traffic is dense, and to a degree, reflected light may aid judgment of speed and distance, although it could well detract from the latter if the background against which vehicles are moving is not adequately bright. Our past experience indicates that it is still necessary to provide a large amount of silhouette lighting for economical roadway illumination with sufficient contrast for safe nighttime driving. This experience also supports the generally recognized importance of comfort from roadway lighting installations.

It will be interesting to see how well the luminaire which Mr. Waldbauer proposes for expressway lighting bears up in actual installation as compared with the DVB computations presented in the paper. We noted that an installation is being made on Route 401 in Toronto, Ont. and this should help to answer some of the many questions which naturally arise.

Since we do not concur in the conclusions drawn by the author, there are several questions we would like to ask.

(1) What are the candlepower distributions assumed by the author to be representative of conventional mercury and fluorescent roadway lighting? It seems that the author's claims with regard to per cent loss due to DVB in these two systems are inordinately high. Visibility factor computations, along the lines proposed by Rex,[1] should be provided for comparison of the various lighting systems under discussion in the paper.

(2) Do the selected observer positions favor the proposed system? The author should show the relationship of the three systems, as given in Table II, when the observer is in a passing lane. DVB computations by the writer, from measurements on a highway lighting test installation,[2] show that the values vary considerably depending upon the driver path in a traffic passing lane under conventional mercury luminaires, as compared to the outside lane. It would seem reasonable to assume that a vehicle driver in the passing lane, being closer to the maximum candlepower beam from luminaires on his left in the proposed lighting system, might suffer DVB loss considerably higher than that shown for the outside, or emergency, lane selected. We should have the complete comparison of visibility and comfort of the author's proposed system *vs.* conventional mercury or fluorescent roadway lighting.

(3) With the vehicle driver in the passing lane, wouldn't there be a considerable "flicker effect" from the luminaires on his left, both from light coming directly toward him and from light reflected from the vehicle surfaces, rear-view mirrors, etc., when the vehicle passes under the proposed directional luminaires?

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(4) Has the author made any discomfort glare comparisons taking into consideration reflecting surfaces as well as the light sources themselves?

(5) Has the author calculated and evaluated the contrast produced by his proposed system as compared to other systems in present use? It would seem that this information should be given.

(6) Has the author given due consideration to the shadow effect ahead of the vehicle as it passes through successive high candlepower beams from luminaires in the proposed lighting system?

Unless the answers to the above questions are quite different from what we expect they will be, we are of the opinion that the proposed lighting system will be found wanting as compared to presently accepted roadway lighting for expressways. If this be the case, the author may wish to modify, considerably, the conclusions he has drawn with regard to visibility and freedom from glare (in all its forms), and his implication as to how poor conventional expressway lighting is.

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2. Nagel, George A.: "A Highway Lighting Test Installation," ILLUMINATING ENGINEERING, Vol. LII, No. 3, p. 162, Fig. 8. (March 1957).

JOHN W. YOUNG:* Lighting systems accomplished by new light distributions are always stimulating. In this paper, Mr. Waldbauer has presented a new concept for highway applications that merits examination and trial. This contribution should increase the sum total knowledge of applying illumination on dual-road, high-speed roadways in particular.

The light distribution principle calls for dealing with strong vertical candlepower beams and resulting glare effects, although such are not observed directly. One could enumerate several points that might have a bearing on the performance of the proposed illumination and which probably have been observed in experiments or considered for resolving in actual application. It would seem that annoying "traveling" shadows might be cast in front of the car (a situation noticed with low mounting of large light sources in bi-directional systems). Conceivably, there are reflections and strong glare from car surfaces, glass windows (sides), from rear-view mirrors, strong beams inside cars and various other surfaces. There is also the situation, possibly, of glare experience from areas adjacent to the highway and the necessity of modification of the light distribution at interchanges, service areas and other locations.

One item on which it is hoped the author will expand is the consideration of mounting height of luminaires. A height of 30 feet is the minimum, very probably, but what is the case for some higher mounting height from a light distribution standpoint, that is, pattern and spacing? Also, would not some greater height subject the driver and other observers to less reflected glare conditions?

It seems that lowered investment and annual operating costs might be substantial with this system. There are factors, apparently, quite favorable compared with present applications.

(a) The 300-foot spacing results in a reduction of lamp units to approximately 18 per mile of roadway as compared with possibly 24-26 and 30 units in some bi-directional lighting done today on dual roadways. In many instances, a reduction of lamp units is virtually the sole opportunity to effect lower investment in highway lighting installations. With underground construction, the savings can be sizable.

(b) One way of rating energy requirements for lighting a given type of roadway is in watts-per-lineal foot of roadway. It is apparent that the wattage for 300-foot spacing results in a reduction of the electrical energy component of the per mile annual maintenance cost as compared with alternate installations frequently done today.

(c) Such a system as proposed, that is, for dual roadway and medial strip arrangement, offers an opportunity for a considerable reduction in the electrical distribution system cost per mile. This comes about by reason of the lamp units being located in the medial strip, primarily for light distribution purposes, of course. For a direct burial wire distribution system, all in the medial strip, trenching (and circuit run) for one tentative layout would be around 65 per cent less per mile of dual roadway than where lamp units are located on the outside of each roadway and served by a distribution circuit for each side.

The author and his associates have made an important contribution in lighting techniques and developments will be watched with much interest.

W. B. ELMER:* Street lighting engineers have speculated, for many years, on the merits of lighting systems other than the almost universally used bi-directional system. As long ago as the early twenties, a system very similar to that described by the author was tried out by Lamson on Boylston Street in Boston and subsequently abandoned. In the late thirties (?), a very slightly modified bi-directional system, in which slightly more light was projected upstream than downstream, was used in Detroit with presumed success. Prior to 1948, a uni-directional system was developed and installed in England, and was reported as successful by J. S. Smyth to the Association of Public Lighting Engineers. In the early 1950's, a low level uni-directional downstream system was installed on the Mystic River Bridge in Boston. This system has been thoroughly condemned because of the reflections in the rear-view mirrors of automobiles. In 1957, I developed a new "directional" lighting system using a large low-brightness mercury or incandescent luminaire. This system was installed, at first experimentally, and later commercially, by both the Connecticut State Highway Department and the Connecticut Light and Power Co., with highly satisfactory results. This system is designated as "directional" to distinguish it from the "uni-directional" system, inasmuch as the normal degree of illumination is projected upstream, whereas the downstream light is limited to about a third of the normal value. More recent experiments with strictly uni-directional fluorescent lighting directed upstream have been adjudged unsatisfactory by Harold Wall of the Detroit Public Lighting Commission.

Against this fragmentary history of directional and uni-directional lighting, we are now presented with Mr. Waldbauer's interesting re-espousal of the hitherto rejected downstream uni-directional system.

In passing, let it be noted that the author's statement on the first page, that "... and now even the Connecticut Turnpike [has] utilized standard bi-directional street lighting luminaires ..." is misleading, ignoring the fact that a substantial quantity of upstream directional low-brightness

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mercury luminaires are being installed on the uncompleted east end.

In his opening discussion, the author rejects upstream lighting for highways because of a supposed hypnotic shutter effect during prolonged driving periods. He has not considered the possibility of installing larger lights at higher elevations and on greatly extended spacing, which would also overcome the shutter effect to a considerable degree, if this effect is truly a hazard. The author admits that his fears are speculative and it should not be forgotten that a rhythmic variation in lighting might have the opposite effect from that which he fears, *i.e.*, the repeated flashing by of overhead light sources may act as a stimulant to keep the driver awake. Certainly, I have never heard that an insomniac can lull himself to sleep by subjecting himself to repeated flashes of light.

I believe that the key to the present question lies in the light level used. It is well-known that discernment by direct illumination is most difficult below five footcandles. Such gloomy levels are only tolerated in churches where a "dim religious light" is required, or in warehouses, where no small objects or fine details need be discerned. Well below this level, in the usual street lighting ranges from 0.2 to 1.2 footcandles, it is traditional knowledge that vision is accomplished by silhouette. This is the first fundamental learned by every young street lighting engineer.

The illumination level at which silhouette vision leaves off and direct discernment begins has probably never been clearly defined. It seems likely that this null region lies somewhere between 5 and 10 footcandles; above 10 footcandles, direct discernment becomes effective; below 5 footcandles, silhouette vision is the medium of perception.

A consideration of contrast will provide a very good answer to this question. Visibility is provided by contrast, both brightness contrast and color contrast, and it is reduced by veiling glare. For the street lighting problem, where an object must be perceived several hundred feet ahead of the moving vehicle, the contrast is expressed by:

$$C = \pm \frac{(B_1 - B_2)}{B_1}$$

where C is always positive,

B_1 = Brightness of pavement behind obstacle,

B_2 = Brightness of obstacle.

In the case of silhouette vision, B_2 is approximately zero, hence contrast is approximately unity. In the case of direct illumination, in order to obtain contrast equal to that provided by silhouette vision (unity), B_2 must equal $2B_1$. If the illumination on the obstacle is double that on the pavement, the contrast will be equal to that obtained by silhouette, provided reflectances are equal. If, however, the obstacle reflectance is half that of the pavement (a common case), the contrast is zero. This is the well-known neutral point that occurs beyond a street light, where visibility can be completely lost unless color, texture or geometric differences exist. This is the reason why higher orders of illumination are required for downstream roadway lighting than for upstream.

For the author to claim satisfactory visibility at one footcandle by direct discernment, therefore, is contrary to all lighting experience. A careful study of Figs. 6, 7 and 8 does not appear to support the claims of satisfactory visibility. The large white target in Fig. 7 is visible only because it extends above the pavement background and because it rises against a line of pavement darkness close behind it. The small white target is hardly visible. The black targets are not visible because of the direct illumination, but despite this, and because of silhouette against the pavement, the upstream directional system would give far superior discernment in all cases. Photographs of a variety of targets of graduated reflectances under both systems would be necessary to reveal the inadequacy of downstream lighting under recommended illumination levels.

It is, of course, highly commendable to seek the elimination of glare. The disability veiling brightness from modern, well-designed luminaires and particularly, in my opinion, from the low-brightness mercury luminaires with their excellent optical system, subtracts not more than five or ten per cent from the excellent silhouette visibility afforded by that luminaire. It would require an estimated 10 to 12 footcandles from the proposed downstream uni-directional system to equal the visibility afforded by 1-1.5 footcandles of upstream light properly distributed, glare notwithstanding. The proposed downstream system, therefore, appears to be impractical on the score of cost, if comparable visibilities are considered.

Before concluding, I would like to request that the author cite the source of data used in the interesting atmospheric absorption chart, Fig. 2.

R. E. FAUCETT:* Mr. Waldbauer is to be complimented for taking a fresh look at the relatively old idea of uni-directional street lighting. C. A. B. Halvorson reported upon similar studies conducted about 20 years ago on a 1000-foot section of the Taconic Parkway near Poughkeepsie, N. Y.[1] The object of these studies, sponsored by H. E. Dexter and M. N. Waterman, then of the Central Hudson Gas & Electric Corp., was to determine to what extent pavement brightness might be enhanced by properly coordinating the design of pavement surfaces with projector-type luminaires pointed generally in the direction of travel. A more recent installation on the Mystic River Bridge was reported by W. J. McClain, J. E. Greiner Co.[2]

The main difference between these earlier studies and the one reported by Mr. Waldbauer is that of mounting height and spacing. Mr. Halvorson's studies used approximately 3½-foot mounting heights and 100-foot spacings, compared to Mr. McClain's 4-foot mounting heights and 52-foot spacings. The present study reports 30-foot mounting heights and 250- to 300-foot spacings. The geometry of any of these installations is such that the angle of incidence of light at the pavement is quite large. Apparently, the Mystic Bridge installation and the present experimental installation have a very similar ratio of spacing to mounting height.

It has been reported by some observers of these earlier installations that light being projected from behind drivers causes glare in the rear-view mirrors, windshield and other specular surfaces, as well as disconcerting moving shadows within the vehicle.

Superficial thinking on the matter may lead one to the conclusion that the shutter effect would be eliminated by a uni-directional lighting system. Actually, this probably is not the case because of the reflected light received by the eye from the automobile's structural and ornamental elements, as well as from other objects along the street such as parked or moving vehicles, signs, etc. There would, therefore, still be a shutter effect. However, the shutter effect existing under a uni-directional system would be "out-of phase" with that which would exist under conventional

*General Electric Co., Outdoor Lighting Department, Hendersonville, N. C.

roadway lighting systems. The reasoning behind this is that the full brightness impact of the source is observed during the approach in a bi-directional system, whereas the full brightness impact is observed after passing the source in a uni-directional system. It is felt that this out-of-phase relationship has no significant effect upon over-all comfort or visibility. The important thing in either case, when considering comfort, is the ratio of the effective glare brightness to the adaptation brightness of the observer, assuming all other factors, such as effective source sizes, position factors, time of exposure and color of illuminant, are constant.

Observers of the earlier studies also reported that a continual impulse to slow down and let the "close-following automobiles" pass existed. A uni-directional lighting system has also been observed to produce moving shadows of the vehicle in its own path. This could, in itself, be very dangerous because the distractions to the driver could more than offset the advantages gained by the illumination.

It is believed that these presently proposed higher mounting heights will help reduce the annoyances pointed out above as being some of the undesirable results of a uni-directional lighting system. In addition to these higher mounting heights, the shutter effect can be further minimized by proper design of the light distribution pattern, including a proper choice of the angle of maximum candlepower.

Mr. Waldbauer states that "... all new roadways built in cooperation with the Federal Highway Program must have medial strips at least 32 feet wide." It should be pointed out that this is merely a recommendation, and certainly a desirable achievement. The Federal Bureau of Public Roads recognizes that this is a very difficult thing to achieve, and is in many cases impossible because of limited area or right-of-way obstacles. Therefore, as a practical result, it is more the exception than the rule, at least at the present time, to find these wide medial strips incorporated into highways.

When medial strips are less than 32 feet wide, appreciable flux is furnished from luminaires mounted over the far roadway. This additional flux can only be ignored when the medial strip appreciably exceeds 32 feet. Most existing heavily-traveled roads that will be lighted, have medial strips less than 32 feet wide.

The author points out that, in general, highway lighting systems are being installed at interchanges, service areas, and access entrances, but not along the highway between these areas. This represents a terrific challenge for the lighting industry. The highway and traffic consultants tell us that there is no existing evidence today to justify lighting areas between interchanges on controlled access highways. There appears to be general agreement that all parts of a non-controlled access highway should be lighted. Therefore, I would like to repeat that it is up to us to offer *proof* of the need of a fixed lighting system on these high-speed, controlled-access highways now being constructed. However, even in the face of this lack of evidence, many urban expressways are being lighted continuously. Atlanta reports over 30 miles of continuous lighting. Chicago, Dallas, Detroit, Fort Worth, and even relatively smaller cities such as Austin, Texas and Winston-Salem, N. C., have continuous systems on modern expressways.

The author recognizes that the Connecticut Turnpike was illuminated by employing conventional bi-directional equipment because "... a great deal of application experience is available." This should be explained a little more in detail because experience has thus far proved that bi-directional equipment is the most economical and practical means of providing optimum visibility on our present day roadways when all factors are considered.

Previous investigations have indicated that uni-directional lighting systems have some merit as long as pavement surfaces remain diffuse in reflection characteristics. On traffic-worn, smooth surfaces or otherwise specular pavements, such as wet concrete, it has been repeatedly concluded that light aimed generally in the direction of travel is ineffective. This has been demonstrated to be the case even on a wet *rough* surface.

Many authorities have recognized the importance of pavement brightness throughout the years. Recently, one stated: "One quantity that seems to be a key to the entire problem is the roadway brightness as seen by a vehicle operator."[8]

The author states that "... the eye discerns most larger objects by direct discernment and certainly cars along the roadway are seen as cars and not just as silhouettes." I am in agreement with the author as long as the roadway is lighted to a relatively high vertical footcandle level. However, it is not necessary that the object be lighted to this high vertical footcandle level if it is seen by silhouette and it is not necessary to have a high brightness background to discern by silhouette. Therefore, not as much candlepower is required toward the eye to achieve threshold awareness by silhouette as is required to achieve threshold awareness by direct discernment. Therefore, despite some glare, the threshold of awareness of objects on the pavement is frequently improved when viewing the roadway in a direction opposing the incident light.

The author points out that: "A fourth possible system for highway lighting would be the use of continuous fluorescent strip mounted off to one side of the roadway." Such a system was installed in October 1956 on an experimental basis, over a 100-foot section of 70-foot wide roadway. Fig. A depicts this installation. Notice the uniformity produced as evidenced by the absence of shadows of the observers in the streets. If properly baffled, such a system could be virtually glare-free. This system has many merits, but a treatise on this installation is beyond the scope of this discussion. This type of lighting technique will become more feasible when high frequency power sources are more commonly available. By high frequency, I do not mean 400 cycles, but rather the kilocycle ranges — perhaps higher.

Figure A. Continuous fluorescent strip lighting over a 100-foot section of 70-foot wide roadway. Eight-foot fluorescent floodlighting units equipped with 96T12 cool white rapid start lamps are mounted on catenary 28 feet above the roadway.

It was stated that: "Up until now, the street lighting designers have paid more attention to the illumination which the system would produce than to the comfort of the motorist." This certainly has not been the case with my company. For years we have been preaching the importance of comfort.[4] Many basic research studies on comfort could be listed, such as the work of Drs. Guth and Harrison, as well as practical application papers by Reid and Toenjes[5] and Rex.[6,7]

On the fourth page of his paper, the author states that "... the most important task of street lighting is to provide visibility." Then on the next page, he says that "visibility is the second most important factor." I assume that the implication here is that comfort is perhaps the most important after all. I heartily disagree. It is my opinion that the most important item is safety. Then, let either visibility or comfort come in second place, whichever one is needed to achieve safety.

It would be interesting to evaluate the evidence on which the author bases his belief that a combination lighting system (one which provides both direct and silhouette discernment)would produce a lower over-all visibility rating than one which provides a direct discernment visibility only. Also, if a uni-directional system (direct discernment) were employed with the units aimed generally in the direction of traffic flow, why should headlights be used at all?

The author has expressed his full realization of the practical difficulties in designing an optical system to meet the practical requirements of the uni-directional lighting system. Therefore, until such time that these practical optical control design problems can be solved, it is recommended that we continue to improve functional performance of products used in the more conventional, experience-proven systems.

I wish to express my sincere appreciation to the author for affording me the opportunity of commenting on this fascinating approach to the problem of seeing on roadways. I also wish to acknowledge the assistance given me by W. E. Schwanhausser in preparing this discussion.

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W. M. WALDBAUER:* I wish to thank those who took the time to prepare the above thought-provoking discussions. It is encouraging to note that the discussers unanimously agreed that it is "highly commendable" to seek the elimination of glare from roadway lighting systems. It is natural that certain questions and doubts are raised in the minds of those who read this paper, since it represents an unconventional and virtually untried departure from the principles currently used in roadway lighting.

Several of the discussers have cited the previous experience of uni-directional systems, especially those on the Taconic Parkway and Mystic River Bridge. These discussers report that there were serious objections to the uni-directional approach based on a reflection received by the driver's car windows, interior surfaces and rear- and side-view mirrors. These installations utilize luminaires at relatively low mounting heights, *i.e.*, 3½ feet as compared with the 32-foot mounting height proposed by the author.

Two test installations of the proposed system have been made thus far. One is located in Cleveland and the other in the outskirts of Toronto. While neither of these systems represents what might be termed ideal installations, observers who have driven under the installations have reported no difficulties regarding reflected glare from various surfaces of the car. Another factor considered by several of the discussers is the probability of annoying effects from "traveling shadows" created by the car itself. Under the proposed system, such shadows do exist and can be quite long considering the relatively small angle of depression of the main beam from the horizontal. However, such shadows are annoying only when driving is done without the aid of vehicle headlights. With the headlights on, these shadows are washed out and no annoying effects are noted.

Several questions regarding the application of this system have arisen and are deserving of further comment. Regarding the modification of the distribution of this luminaire at interchanges, service areas and the like, it is my opinion that this system would find its principal use along dual-lane roadways between interchanges and service area points. At interchange and service areas themselves, either conventional bi-directional luminaires or another type of "no glare" luminaire would be required.

Regarding the question of medial strip width, the present luminaire is being developed for medial strip widths of 32 feet or more. As the optical system is further developed, and the cut-off of the luminaire improved, medial strips less than 32 feet in width will be in order. It should also be remembered that the current recommendations of medial strips 32 feet in width or greater are based on achieving a certain reduction in DVB as compared with current roadway lighting systems. Even in its current state of development, the luminaire could be installed on medial strips less than 32 feet wide but only with a resulting increase in DVB.

Regarding the source of data for Fig. 2, these were calculated using Bouger's or Lambert's law with the value of the exponent "X" having been determined from the data given on pages 9-44 and 15-21 of the *IES Lighting Handbook*, Second Edition.

While much work remains to be done before this proposed lighting system becomes a practical reality, my company has more than a theoretical interest in "lighting without glare." The development of the high utilization fluorescent street light, mounted parallel to the curb, together with this development adequately provides proof of this statement. In addition to this, the company has continued to provide improved developments in the field of bi-directional lighting as well as in the associated field of improved light sources. While providing visibility is our most important task, we must make sure that in attempting to improve visibility with higher illumination levels, we have not sacrificed driver comfort or over-all visibility.

*Author.

Design of Fluorescent Lamps For High Frequency Service

By GEORGE A. MEYERS
F. M. W. STROJNY

Introduction

High frequency operation of fluorescent lamps has received much attention in recent years because of real gains in lamp performance and potential gains in the over-all cost of an installation. Papers which have described various systems, many pioneer or experimental, have shown several ways in which to handle the problems of lamp performance,[1,2,3,4] frequency conversion equipment[6,7] and distribution systems.[5,6] In the present transitory state of the art, it is not surprising that there has been no standardization of system frequency or apparatus. Continued studies can be expected to further establish optimum lamp operating conditions and to resolve the problems of economic conversion equipment and power distribution. This paper will be concerned with the factors which influence lamp performance and the lamp design parameters which are affected.

Test Equipment

The frequency conversion equipment used in this work consisted of a 500-watt vacuum-tube power amplifier with a variable frequency range of 20-5000 cycles. A sine wave output was normally used but could be altered by the proper choice of input signal. Instruments were a vacuum-tube voltmeter and wattmeter with a frequency range of 20-20,000 cycles and an accuracy of ±2 per cent. The thermocouple ammeters used had an error of less than 1 per cent up to 15,000 cycles. Transformers were of the highest quality audio type and were used for tests above 400 cycles, where necessary.

Lumen Output and Efficiency

One attraction of high frequency operation is improved lamp efficiency. This may be gained, however, at the loss of actual light output unless a compensating increase in lamp current is made. Fig. 1 shows the lumen output, relative to 60-cycle ratings, of T12 lamps operating at constant current on iron-core inductive ballasts and two levels of wattage loading. The loss in brightness appears to be an inverse function of loading below approximately 2500 cycles, while a gain is shown above this point. On a capacitive ballast, a further increase in light output of 3 to 6 per cent is achieved at frequencies above 2500 cycles. This is apparently related to the characteristics of the iron used in the inductor, since a similar improvement is shown if air-core inductors are used.

The efficiency of 96 T12 lamps at two loadings is shown in Fig. 2, plotted in per cent of 60-cycle values. The lamps were operated at constant cur-

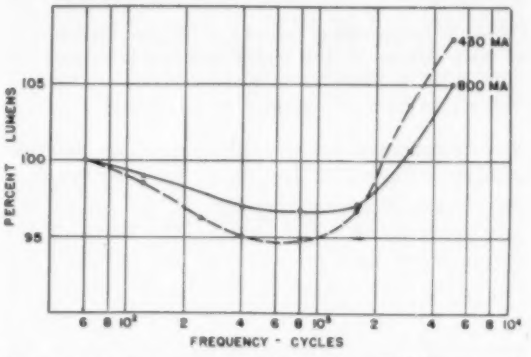

Figure 1. Lumen output vs. frequency. T12 lamps operated on inductive ballasts at constant current. Values are relative to 60-cycle ratings.

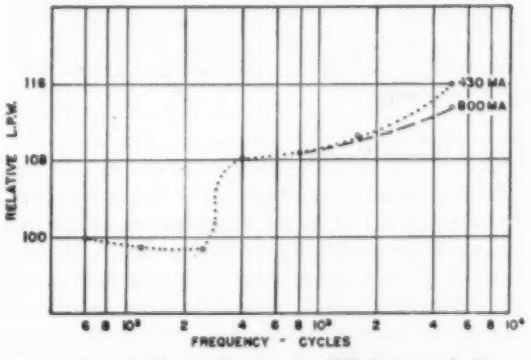

Figure 2. L.P.W. vs. frequency. Efficiency, relative to 60-cycle ratings, of 96 T12 lamps operated on inductive ballasts at constant current.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, August 17-22, 1958, Toronto, Ont.
AUTHORS: Sylvania Electric Products, Inc., Danvers, Mass.
This paper accepted by the Papers Committee of I.E.S. as a Transaction of the Illuminating Engineering Society.

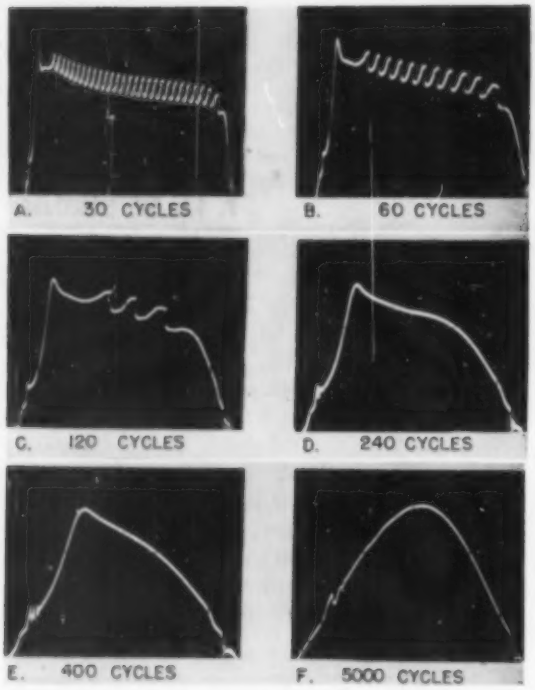

Figure 3. Lamp voltage waveshape. Typical oscillograms of lamp voltage of T12 lamps operated at several frequencies on inductive ballasts.

rent on inductive ballasts. Because of the decrease in lamp voltage with frequency, the lamp wattage also decreases proportionately. If the lamps had been operated at rated wattage, the shape of the curves would have been similar, except that their magnitude would have been reduced by approximately one-half. Instant-start and high output rapid-start lamps show a substantial gain in efficiency above 400 cycles, which increases further with frequency. The jump in the curve between 240 and 400 cycles is due to the large improvement in lamp voltage waveshape, as shown in Fig. 3, and a subsequent drop in lamp wattage. In every case, the greatest gain in output and efficiency is obtained by operating the lamps at the highest practical frequency.

Lamp Power Factor

The apparent power factor of a fluorescent lamp at 60 cycles is due to the harmonic content in the lamp voltage, as illustrated in Fig. 3b. A Fourier analysis of such waveforms shows the presence of the third, fifth and seventh harmonics plus a substantial series starting at about 2000 cycles due to anode oscillations — the sawtooth effect at the top of the waveform. This is difficult to handle in circuit analysis and one must generally resort to empirical approximations.[5] As the supply frequency is increased the harmonic content decreases so that by 400 cycles the lamp becomes very nearly a pure resistance and may be treated as such with only a small error. Improvement in lamp power factor with frequency for lamps operated on inductive ballasts is shown in Fig. 4.

Electrode Losses

Power loss at the cathode determines the cathode efficiency, operating temperatures, and many of the electrode design parameters which the lamp designer must adjust to achieve a practical electrode structure. Since this loss is expressed as heat, whether it be a cathode loss or an anode loss, a measurement of the amount of heat produced at the electrode can be related to the effect of various operating conditions such as lamp current or power supply frequency. Fortunately, since lamp cathodes operate at temperatures in the vicinity of 1200K, a large amount of the power radiated will be within the spectral sensitivity limits of infrared detectors such as the lead sulphide cell. Such a cell was used in the scheme shown in Fig. 5 which had an over-all spectral response of 7300 to 27,000 angstroms. An image of the cathode structure was focused upon a Kodak Ektron detector through an infrared filter to eliminate the radiation from the mercury or phosphors of the lamp. The reduction in cell resistance due to radiation was balanced out in a simple bridge circuit and the relative change noted. The second cell ED′ is part of the bridge circuit to compensate for the effect of ambient temperature and humidity. Of course, this system could not be used for absolute measurements or over a wide range of temperature, but it was useful as a tool to help appraise relative cathode performance at high frequencies and it gave results which were in reasonable agreement with other measurements.

With lamps operating at constant current, the

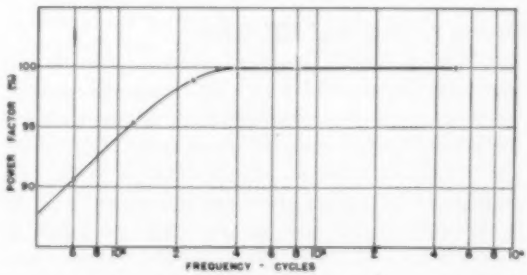

Figure 4. Power factor vs. frequency. Average per cent power factor of 96T12 lamps operating at constant current on inductive ballasts.

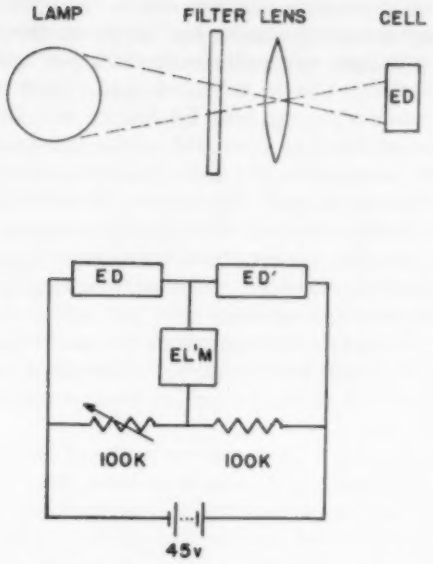

Figure 5. Bridge circuit for measuring relative cathode loss. ED—Kodak Ektron detector, 10 x 5 mm., type II. EL'M—Kiethley Electrometer, model 200A. Filter—Wratten No. 88A.

relative change in electrode loss as a function of supply frequency is shown in Fig. 6. A substantial reduction is shown, with the greatest decrease occurring between 60 and 400 cycles. The curve for zero cathode volts, *i.e.*, a self-heated cathode, is similar for the several size cathodes used in these tests. When the cathode was heated from an external source, as is normal in rapid-start systems, a further reduction in cathode loss occurred exclusive of the power added for cathode heating, and appeared to be optimum between 3.0 and 3.5 volts. No difference in cathode performance could be found between heating the cathodes from a 60-cycle

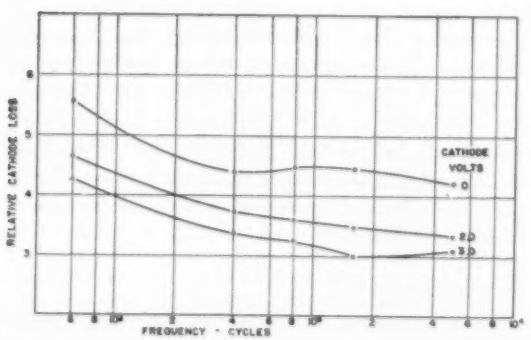

Figure 6. Cathode loss vs. frequency. Relative cathode loss of T12/HO lamps with cathodes heated at several values of cathode voltage. Lamps operated on inductive ballasts at 800 ma.

supply or from the higher frequency of the lamp current supply. In some instances it may be simpler or more economical to furnish cathode heat from a 60-cycle system than to use the more expensive high frequency power.

The largest reduction in cathode loss at high frequencies occurs in lightly loaded lamps such as the preheat and instant-start 430 ma types. This suggests improved lamp life to a significant amount, but the reduced lumen output below 3000 cycles requires an increase in current for compensation if rated output is desired. At 400 cycles, an operating current of 600 ma will produce the same cathode loss as 400 ma at 60 cycles, thus justifying the present general practice of operating T12 slimline lamps at 600 ma. A similar increase might be justified for high output types on the same basis; an operating current of 1100 ma at 400 cycles yields the same cathode loss as 800 ma at 60 cycles. Since the lamp is already highly loaded, a lower value, such as 1000 ma, would be adequate to compensate for loss in brightness and at the same time insure good life and efficiency.

Electrode losses below 400 cycles are very dependent on the type of circuit used. A capacitive ballast will increase losses by nearly 25 per cent at 240 cycles, which may be associated, in part, with the high current crest factors obtained below 400 cycles.

Starting Voltage

The open-circuit voltage that is required to start instant-start or rapid-start types is of particular interest to the circuit designer. Unless starting pulses, "resonant-start" principles or other schemes are used for lamp starting purposes, the magnitude of open-circuit voltage required for starting will play a major role in the required volt-ampere ratings of equipment and the degree of lamp operating stability achieved. Fig. 7 shows the manner in which lamp starting voltage varies as a function of frequency for several T12 lamps in two lengths. Measurements were made by slowly raising the voltage from a sine wave source until the lamp started. All lamps were at normal room temperatures and were mounted within one inch of a grounded metal starting aid; rapid-start types had cathodes heated at 3.6 volts. In most cases the starting voltage increased with frequency, in one instance as much as 25 per cent above the 60-cycle value. No pattern is apparent but it is evident that the circuit or ballast designer cannot use data published for 60-cycle service but should obtain recommended values for the particular lamp, frequency and system waveshape to be used, and for the ambient temperatures to be encountered.

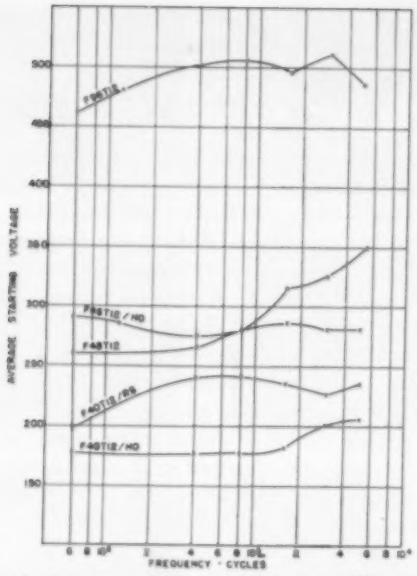

Figure 7. Starting voltage vs. frequency. Measured at room temperature with sine wave voltage source. Rapid start cathodes heated at 3.6 volts.

Radio-Frequency Interference

A frequent source of annoyance with fluorescent lamps arises from their ability to generate interference with radio and television reception. The noise reducing capacitors in starters or ballasts are not always adequate to cope with all lamps because they vary widely in the amount of noise produced.

In order to get an appraisal of the relative reduction in noise which might be expected to occur at high frequencies, a Hammarlund HQ-100 receiver with a small loop antenna and a millivoltmeter connected across a dummy load on the speaker output terminals was used to measure the relative noise produced in the broadcast band. The method was similar to that used by Shorey and Gray.[9] Care was taken to filter and isolate the receiver power line so that the noise measured would be only that picked up by the antenna. Both lamp and receiver were operated within a screened enclosure, with the lamp two feet from the receiver antenna. As might be expected, the lamps were very inconsistent in producing noise. The best method found for getting relative measurements was to find a noisy lamp and vary frequency or operating conditions without extinguishing the lamp or moving it in any way.

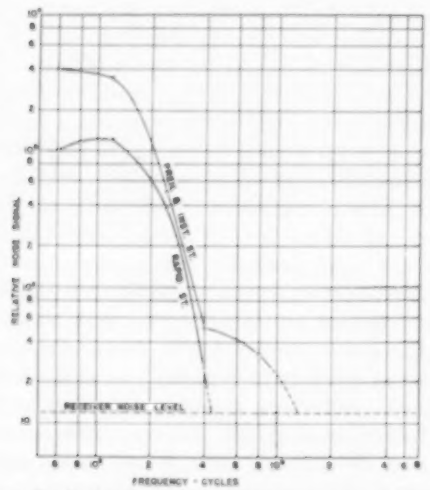

Figure 8. Radio frequency interference vs. frequency. Relative noise signal produced in broadcast band by 24-inch lamps operated at several frequencies.

The largest noise signal was produced at the low frequency end of the broadcast band, but because of the very random nature of noise produced from each lamp a value, averaged across the 540-1600 kc band was used in Fig. 8. Here it is evident that high frequency operation results in a reduction of noise by several orders of magnitude, to the extent that a noise problem does not exist.[10] What little may remain can be adequately handled by suitable filter capacitors. No attempt was made, however, to determine the amount of interfering radiation produced in television channels. Culp[11] showed that the noise produced by lamps was of several types which he termed "re-ignition noise," "anode noise" and "hollow-cathode noise." Because a state of dynamic equilibrium exists in the arc at high frequencies, as shown by lamp voltage waveshape (Fig. 3e) or volt-ampere oscillograms,[1] no potential rise for re-ignition of the arc each half cycle is necessary, hence no radio-frequency noise is generated. The anode oscillations on the top of the voltage wave (Fig. 3) also disappear above 400 cycles, and presumably the radio-frequency noise associated with them does likewise. "Hollow-cathode" noise is generated by the action of the cathode hot-spot and is probably responsible for the greater amount of noise produced in lamps with self-heated cathodes, as shown in Fig. 8. While this effect may not disappear at high frequencies, it is probably reduced in cathodes of the rapid-start type which do not rely on self-heating. Beyond these conjectures no effort was made to determine the source of noise in lamps.

Conclusion

High frequency operation of fluorescent lamps results in improved efficiency and power factor, the virtual elimination of radio frequency interference and reduced cathode losses. An increase in current loading can be tolerated, with a consequent gain in

lumen output. Some increase in starting voltage requirements is the only adverse factor to be considered. The minimum useful frequency for a sine wave voltage supply is 300 cycles, if capacitive ballasting is used; maximum gains in lamp performance are achieved at the maximum frequency that can be supplied. This paper supplements and corroborates other studies of lamp performance in this respect. Substantial correlative gains are found in the reduction of ballast size, cost, noise and efficiency. The optimum system frequency, therefore, is the best engineering compromise among improvements in lamp performance, conversion equipment cost and efficiency, ballast cost and distribution requirements.

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DISCUSSION

J. H. CAMPBELL:* This is a very interesting and thought-provoking paper describing some of the fundamental characteristics of fluorescent lamps on high-frequency power. Although the data are presented in a somewhat different form, they confirm, in general, much of the previously published information on this subject and add an interesting method for determining reduction in electrode losses.

It occurs to me that the data shown in Fig. 1 would be in better perspective if per cent lumens were shown with constant watts as well as with constant current. As the authors point out, maintaining rated lamp current as frequency increases brings about a reduction in lamp volts, watts and lumens. However, at a point between 600 and 1000 cycles, this trend reverses, and rated lamp watts approach the 60-cycle value at about 6000 cycles. At this point, our data for the 96T12 slimline lamp indicate an increase of eight per cent in lumens and efficiency over the 60-cycle rating. If, on the other hand, lamp watts are maintained, lamp lumens will increase in direct relation to the increase in lamp efficiency at each point in the frequency

*Lamp Division, General Electric Co., Cleveland, Ohio.

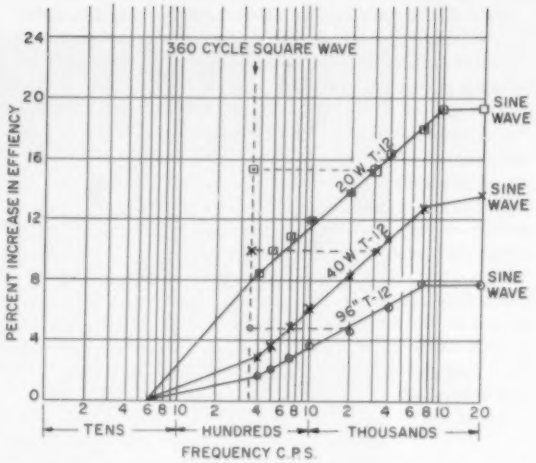

Figure A. Lamp efficiency vs. frequency for sine and square current wave form.

range. This is best illustrated by the accompanying family of curves (Fig. A) showing the rise in lamp efficiency when watts are held constant for T12 lamps of three lengths. The curves represent the per cent increase in efficiency as frequency rises, with lamps operating on a sine wave of current at rated watts. When lamps are operated on a square wave of current at 360 cycles, efficiency increase is equivalent to that of a sine wave at 2000-3000 cycles, as shown. A square current permits lamps to be operated at higher loadings, and consequently there is greater lumen output. Designers of frequency conversion equipment should consider the feasibility of providing fluorescent lamps with square current, but allow over-all system economics to determine the frequency.

Lamp characteristic data presented to the Society at previous Conferences indicated that a reduction in electrode losses as frequency increased was largely responsible for the rise in lamp efficiency. This paper describes an interesting method for relative measurement of these losses over a wide frequency range. However, the method appears to be very conservative, since actual reduction in lamp watts, according to our data, is greater than the reduction shown in Fig. 5 of the paper. In fluorescent lamps of equal diameter, the end losses are the same for the same current and frequency regardless of lamp length.

A statistical approach to the determination of end losses by H. E. Schultz provides the following comparison. If we take the quantitative measurements of lamp characteristics for several lengths of lamps of the same diameter, operating at the same arc current, an average of arc watts per unit length can be obtained. On this basis, a 96T12 lamp operating on 60 cycles at 800 ma with zero preheat voltage has 92.2 watts in the positive column and 12.6 watts in end losses. At 400 cycles, these values are 90.6 and 7.6 watts respectively, showing a reduction of 40 per cent in end losses. Measurement of these losses by the infrared method showed only 27 per cent reduction as indicated by the upper curve of Fig. 5. Our data further revealed only a negligible change in the positive column efficiency up to 400 cycles. Apparently, the reduction of electrode losses accounts for the entire increase in lamp efficiency in the range of 60-400 cycles. Additional work is needed to establish satisfactory reasons for the increased efficiencies above 400 cycles.

Since the infrared method showed considerably less reduction, it might be assumed that the optical system in the apparatus absorbed some of the energy in the long wave infrared region where changes may be greatest.

With regard to starting voltage characteristics, we have also experienced erratic results in arriving at a specific minimum value for given frequencies. There appears to be no reason why lamps of different lengths and the same diameter exhibit opposite starting characteristics with change in frequency. A test involving a considerably larger number of lamps may be required before specific values can be determined.

We have also observed a marked reduction in radio noise generated by the lamp as power frequency increases. As pointed out by the authors, reduction of noise is coincidental with (but not necessarily because of) elimination of anode oscillations and the establishment of a more stable cathode hot spot.

G. A. Meyers and F. M. W. Strojny:* From a lamp design standpoint, operating lamps at constant current yields more useful data than does operating lamps at constant wattage, and for this reason, the work described in the paper was done at constant current. Since, in practice, most lamps are burned at rated wattage, adding the constant wattage curves to Fig. 1 and 2 would have been edifying to the lamp user, and we thank Mr. Campbell for his data.

*Authors.

The use of a lamp current waveshape having a high harmonic content — approaching a square wave — results in improved lumen output and efficiency and should certainly be considered, as Mr. Campbell suggests, by the designers of conversion equipment. We do not think it likely, in the present state of the art, that devices capable of producing square wave lamp current will be competitive with other converters such as simplified rotary equipment or semiconductor devices.

The measurement of relative electrode losses by the infrared method was chosen over the thermopile technique on the basis of stability and expediency, and is useful where comparisons on a relative basis are adequate. The ordinate scale in Fig. 5 should be labeled, properly, "Relative *Electrode* Loss." A recheck of our original data has shown losses to be in the same order as calculated by H. E. Schultz; certain correction factors originally applied have been found to be unnecessary. We agree that the improvement in efficiency below 400 cycles is primarily due to a reduction in cathode loss, but the mechanism by which improved efficiency is attained in the positive column at the higher frequencies is still under study.

We also agree that the data on lamp starting *vs.* frequency is inconsistent and requires further study for clarification. The values shown in Fig. 7 were rechecked several times on an adequate random sample and repeated well. Starting aid potential in these tests was maintained equal to open-circuit voltage; perhaps its influence on lamp starting varies with frequency and lamp length in a manner which contributes to this anomalous behavior.

Floodlighting without Standards

The customer insisted that in the floodlighting of this office building no standards or poles be used. Equipment was, therefore, mounted on the canopies with specially fabricated angle iron racks. On the north side of the building, the racks have six 1500-watt floodlamps and four 500-watt. On the west side, two 1500-watt floods and two 500-watt are used.

Reflection factor of the building is about 60 per cent. Average illumination reading, from second to eighth floor, is 16 footcandles.

This installation was entered in the Cornhusker Section's contest for My Most Interesting Lighting Job, by John Sinovich and Donald Nelsen, of Evans Electrical Construction Co., Omaha, Nebr.

A.I.A. File No. 31-f

INSTALLATION AT TOUHY AND CICERO AVENUES, LINCOLNWOOD, ILL.

Outdoor Lighting of a Service Station

LIGHTING OBJECTIVE: To illuminate the service areas and general area of a service station for nighttime operation and to provide eye-catching illumination with a minimum of discomfort glare.

GENERAL INFORMATION: This service station is located at the intersection of two main thoroughfares. The lot, which is oddly shaped, measures approximately 75 feet by 135 feet. The service building is faced with a white enameled surface.

INSTALLATION: Nine Revere Electric Mfg. Co. catalog No. 9708-V aluminum luminaires, each equipped with four 96-inch T-12 cool white VHO rapid start fluorescent lamps and door frames using Corning No. 99 Alba-lite glass, are located as shown in Fig. 2. Each luminaire is mounted at an angle of 15 degrees above the horizontal at a height of 14 feet 6 inches above ground, on an octagonal steel pole.

Fig. 2, an isolux diagram for the service station, shows the locations of the above nine luminaires and the illumination values at the service and general areas. Some of the illumination along the Touhy Avenue side is provided from Type III street lighting luminaires equipped with 400-watt E-H1 mercury lamps. The illumination at the building is provided by 12 Kelso-Burnett Co. special canopy units, each equipped with one 72-inch T-12 cool white HO rapid start fluorescent lamp.

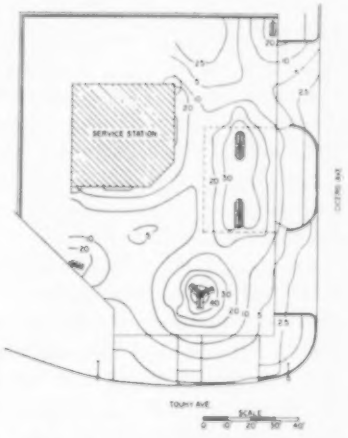

Figure 2. Isolux diagram showing location of luminaires and illumination values.

Lighting designed by Standard Oil Co. of Indiana; installed by Kelso-Burnett Co., Chicago, Ill.

Lighting data submitted by Wallace W. Weld, Barney Jeffers and Michael Joyce, Revere Electric Mfg. Co., Chicago, Ill., as an illustration of good lighting practice and to aid in the design of similar lighting installations.

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Views and Opinions

Esthetics in Fixture Design

One need which becomes increasingly apparent is for a man in the electrical consultant's office who devotes his full working day to esthetic lighting applications. Architects are insisting upon lighting fixtures which will not only supply the necessary light but also become part of the architecture itself. Procedures of fixture selection in the engineer's office follow a time-wasting pattern and often leave the client seeking other engineers who will provide his future designs with the type of lighting he visualizes.

The many electrical requirements of modern installations are such that the engineer can spend little time in a search for appropriate fixtures. He usually selects units which, he has calculated, will give the necessary light and often resorts to recessed fixtures because, in appearance, they are the least objectionable. Illustrations of the fixtures are presented at the next job discussion, with most of them being rejected by the architect.

The engineer returns to his office in despair; he must stop work on other electrical features to thumb through catalog after catalog, hoping to find acceptable fixtures. Very often an entirely new design is called for, resulting in a usually exorbitant and fictitious charge for the manufacture of the fixture. No one can blame the engineer, because he is not trained to design for esthetics and he can not devote his time to a lengthy hit-or-miss process of making sketches, hoping that one will please his client. The final result is a compromise, a dissatisfied architect and a frustrated engineer.

Lighting is approached by the architect as a necessary evil. He has learned from past jobs that the engineer does not view his designs in the same perspective as he does. The consultant's attitude sometimes is "esthetics-be-hanged." In return, architects are not always sympathetic toward engineered lighting, and hesitate to concede the value of a well-lighted job if they feel the appearance of the design will suffer. Architects have said jokingly that they would prefer to hand out flashlights at the door rather than hang a fixture from the ceiling.

It would appear that what is needed is a liaison between engineering and architectural designing, "a man who devotes his full working day to esthetic lighting applications." The architectural lighting designer by necessity should be an artist. He must be an artist fully versed on lighting problems and fixture components and should be familiar with designs already on the market. His capabilities must include the ability to discuss the architectural features, fully understanding the thoughts and meaning of the structure's design. In effect, he must receive the same elation the architect experiences when he discusses the concept of his design.

In presenting the fixtures he has selected, the lighting specialist should submit not only catalog illustrations but also drawings and sketches to bring depth and meaning to his choices. Above all, his efforts should be channeled to gain the confidence of the client that maximum effort is being made to design for his desires. All compromise must be ruled out.

The architect is our client, and unless we want to lose our client, lose lighting fixtures from our contracts, and more probably have the architect some day assuming all engineering responsibilities, serious thought must be given to providing the help that he so greatly needs. — ROBERT A. GALEMMO, *Sharon Hill, Pa.*

NEW IES Recommended Levels of Illumination — how they were determined, what they are. Reprints of the August 1958 IE feature on the hottest subject in the lighting industry are still available (latest printing makes a total of 20,000 copies distribution). Twenty cents each in any quantity. Order from Publications Office, Illuminating Engineering Society, 1860 Broadway, New York 23, N. Y.

LIGHTING NEWS

New York To Be Host to 28th ISCC Meeting

The Inter-Society Color Council will hold its 28th Annual Meeting in New York City's Statler-Hilton Hotel on Wednesday, April 1, 1959. A business meeting is scheduled for the morning session, and a symposium on "The Use of Material Standards for Color Matching," moderated by Program Chairman W. J. Kiernan, will be held in the afternoon. At the evening banquet, Deane B. Judd, National Bureau of Standards, is scheduled to address the delegates on his personal experiences in the field of color and material color standards.

Symposium program and speakers are as follows:

Material Color Standards, Practical Problems and Approaches — A. J. Benjamin, Monsanto Chemical Co.
Material Color Standards, The Instrumental Approach — Harry J. Keegan, National Bureau of Standards.
Material Color Standards, The Visual Approach — Hugh Davidson and Henry Hemmendinger, Davidson & Hemmendinger.

During the evening prior to the conference, the Interchemical Corp. will be host to the ISCC members at its "Color Center."

Advance registration blanks for this Meeting are available from Ralph M. Evans, Secretary, ISCC, Color Technology Division, Building 65, Eastman Kodak Co., Rochester 4, N. Y.

ASHAE, ASRE Members Vote Approval of Merger

The American Society of Heating, Refrigerating and Air-Conditioning Engineers was organized early in December, as the members of the American Society of Heating and Air-Conditioning Engineers and the American Society of Refrigerating Engineers approved the proposed merger of the two groups. The consolidation was announced jointly by ASHAE President Cecil Boling and ASRE President E. R. Queer after balloting at the ASRE Semi-Annual Meeting in New Orleans, La. and the ASHAE Special Meeting in Chicago.

Ninety-three per cent of the heating and air-conditioning engineers and 73 per cent of the refrigerating engineers voted in favor of the merger, well over the two-thirds majority of the total vote required to effect the consolidation. This move followed a long period of exploration, planning and discussion by the Councils of both Societies.

Western New York Section Gives Commercial Lighting Course

Following the success of two previous courses in Industrial Lighting, the Western New York Section of IES this year offered a course in "Principles of Commercial Lighting Design." The program, consisting of six meetings, was held in Buffalo during October and November.

In keeping with the IES desire to extend lighting education to persons outside the lighting industry, registration for the course included "students" from the offices of architects and consulting engineers, as well as from the offices of electrical contractors, wholesalers and other members of the local electrical trade.

Registration for the six-session course was 58, with an average meeting attendance of 50.

Industrial Automatic Systems — Newest NEMA Section

Representatives of a group of manufacturers of industrial automatic systems met at NEMA Headquarters in late November to draw up plans for the formation of an Industrial Automatic Systems Section of the National Electrical Manufacturers Association. The member companies produce systems that operate machines performing certain manufacturing functions in accordance with prescribed plans, with little or no manual guidance.

The new Section will devote its initial efforts to the development of product standards so that future components for industrial automatic systems will measure up to the rigid requirements demanded in the face of the adverse environmental and operational conditions encountered in industrial plants. Many of the components now in use for such systems were developed primarily for office and communications equipment rather than for industrial application.

Elected as Chairman of the Section was D. L. Pierce, Motor and Control Division, Westinghouse Electric Corp., Buffalo, N. Y., with H. L. Palmer, Specialty Transformer Division, General Electric Co., Waynesboro, Pa., named as Chairman of the General Engineering Committee.

Electrical manufacturing companies represented at the November meeting included Cutler Hammer, Inc., Square D Co., General Electric Co., Minneapolis-Honeywell Regulator Co., Westinghouse Electric Corp., Allen-Bradley Co. and Reliance Electric and Engineering Co.

Super Market and Garden Lighting Studied at CLI Clinics

The Chicago Lighting Institute, continuing its program of clinics on various aspects of illumination, recently held sessions devoted to lighting for super markets and lighting for gardens. In association with the Cooperative Food Distributors of America, the National Association of Retail Grocers and the Super Market Institute, the CLI presented, on December 11, 1958, a clinic entitled "Light and Color for the Super Market." The program, covering all phases of lighting of special interest to super market operators, store engineers, architects and designers, was as follows:

Morning Session

Chairman — Ralph Ernst, Architect and Store Engineer, National Associaiton of Retail Grocers.
Demonstration of Institute "Light Center" — Carl W. Zersen, Managing Director, Chicago Lighting Institute.
Seeing Research and Self-Service Selling — Alfred Makulec, General Electric Co., Cleveland, Ohio.
Influencing Buying with Color — Louis Cheskin, Director, Color Research Institute of America.

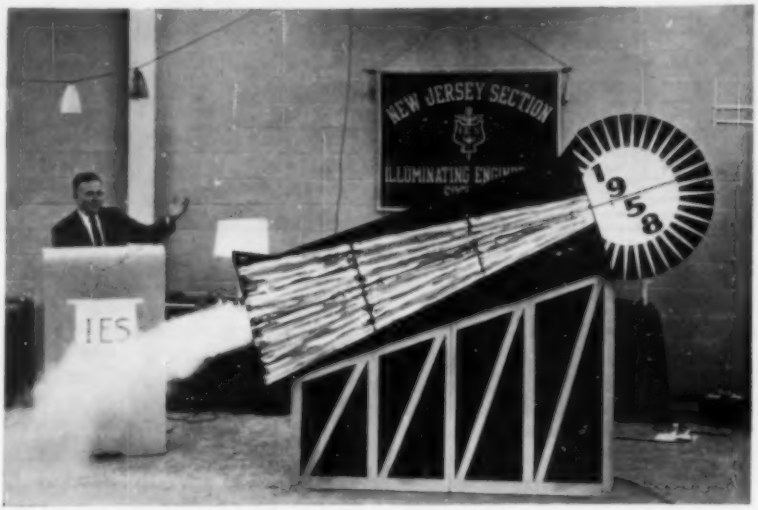
Afternoon Session

Chairman — R. A. Higgins, Director of Education, Super Market Institute.
Lighting Practice for General Seeing—William Weibel, Curtis Lighting, Inc.
Merchandising with Light — Ted Mikita, Garden City Plating and Manufacturing Co.

(Continued on page 9A)

(Continued from page 7A)

Here and There With I.E.S. Members



Chairman of the Progress Committee, E. A. Linsday, is shown presenting the 1958 Progress Report at a meeting of the New Jersey Section.

Featured at the Cornhusker Section's full-day Fall Lighting Conference in Columbus, Nebr. were lighting engineer, James J. Burke, speaking on mercury vapor lamps, and architect Emiel J. Christensen, speaking on community planning. Also included in the day's program was a tour of two of the city's modern industrial plants.

Color is the subject of the present series of lectures being conducted by the Southern California Section Study Club. Shown, in photo at left, at a recent meeting in this series are, left to right, Study Club Chairman Jim Grant, speakers, Bob Clubley and D. R. Graham and Nick Ivanicki, coordinator for the color lectures. Following the Study Club gathering, J. S. Hamel (standing in photo at right) spoke on Lighting at the World's Fair, and Ted Shepherd gave a resume of the National Technical Conference, before a regular meeting of the Section.

(*Continued from page 7A*)

Lighting Maintenance, Cleaning Methods and Group Replacement of Lamps — James Burke, Westinghouse Electric Corp.
Trends in Super Market Design — Walter H. Sobel, Architect.
Concluding Remarks and Discussion Period — R. O. Harb, Cooperative Food Distributors of America.

On display at the Institute during the entire month of January is a demonstration of the latest ideas in home lighting fixture design and special exhibits on garden lighting. In conjunction with the latter, the Institute arranged to present, during both mornings and afternoons, on January 13th and 15th, a group of free lectures on "Lighting for Gardens and Outdoor Recreation."

The lecture program consisted of:

Garden Layouts — Arthur Tyznik, Landscape Architect, Assistant Director of The Morton Arboretum (January 13th) and Nels J. Johnson, Landscape Instructor, Maine Township High School (January 15th).
Lighting Your Garden — Kerr Sanders, Chicago Lighting Institute.
A New Kind of Night Life (Back Yard Recreational Lighting) — Edward Joiner, Advertising Manager, Steber Manufacturing Co.
New Concepts in Home Lighting — Rose Coakley, Home Lighting Consultant, Moe Light Division of Thomas Industries, Cincinnati, Ohio.

Chairman for all garden lighting sessions was Mrs. J. E. Vandivere, President of the co-sponsoring organization, the Garden Clubs of Illinois, Inc.

IES Local Activity Meetings Formulate 1959 Plans

One of the promising programs resulting from the new Headquarters organization, with expanded field service, has been the over-all planned series of Local Activities meetings at the Regional level. So far this year, each IES Region has held such a meeting to discuss their plans for the year, with emphasis on the individual circumstances of the Region. Also added this year, when possible, was the attendance by National Officers and A. D. Hinckley, Managing Director of IES.

Certain items on the agenda of Regional Local Activities meetings are standard — membership, Section or Chapter meetings, joint meetings with other organizations, MMILJ contests, Allied Arts programs, nominations for new officers, and the like. Some aspects of local activity are more pressing in some Regions than in others, and in some cases problems exist indigenous to the area, such as more difficult transportation in the Pacific Northwest and the possibility of adding Alaska to the territory of that Region.

The South Pacific Coast Region was off to an early start this year, its Local Activities Committee holding their or-

INTER-MOUNTAIN Regional Activities. Left to right: W. M. Stultz, Southern Colorado; C. B. Bell, Southern Colorado; A. D. Hinckley, IES Managing Director; A. E. Fleming, Inter-Mountain Regional V-P; G. H. Patterson, Rocky Mountain Section; J. W. Lowder, Utah Section; L. J. Carlon, Rocky Mountain. Also present was L. S. Reed, Rocky Mountain Section.

MIDWESTERN Regional Activities. Standing, l. to r.: J. R. Chambers, General Secretary; A. D. Hinckley, Managing Director; J. A. Schneller, Director; Brooks Chassaing, Midwestern Regional V-P; D. N. Schneider, Central Illinois Chapter. Seated around table, R. F. Gruhl, Iowa; E. W. Schoenherr, Iowa; R. J. Present, Milwaukee; F. E. Foster, Cornhusker; C. G. Cristensen, Cornhusker; Edwin Schnoll, Milwaukee; Miss Beverly Johnston (recording secretary, on loan from Central Illinois Lighting Co. of Peoria); John Newhouse, John Bahnak and F. T. Tillemans, Twin City; Ernest Gallet, Chicago; Robert Hovind, Central Illinois; J. J. McLaughlin, and Ben Avery, Chicago; Charles Zurheide, St. Louis, and Lee Widigen, Iowa. Also present, Harold Young, Central Illinois.

SOUTHEASTERN Regional Activities. Seated, l. to r.: S. J. Andre, Georgia; R. E. Faucett, Palmetto; E. C. Gatewood, Tar-Heel; National Director J. D. Mitchell; Southeastern Regional V-P James Banton; National Vice-President J. B. Browder; J. J. Burns, Georgia; Paul Foster, Florida; T. L. Cordle, Tar Heel. Standing: R. C. Bythewood, Georgia; Harry Turner, Suwanee River; M. L. Harkey, Jr., Florida; James Lowe, Tar Heel; E. D. Stevens, Tar Heel; Judd Lough Georgia; William Cantrell, Georgia and T. W. Haslam, Georgia. Also present were K. D. Tobin, Palmetto; Nine Faye Bonner, Georgia; R. J. Kuzell, Georgia, and V. H. Beaubam, Georgia.

ganizational meeting last July. The Canadian Region likewise "jumped the gun" on the new fiscal year, organizing its local plans at their meeting during the Toronto Conference in August. The other Regions followed suit: East Central, September 26, Harrisburg, Pa. (see photo page 8A, December IE); Pacific Northwest, October 24, Spokane, Wash.; Midwestern, November 3, Peoria, Ill.; Intermountain, November 10, Denver, Colo.; Great Lakes, November 14, Cleveland, Ohio; Southeastern, November 17, Atlanta, Ga.; South Central, November 19, New Orleans, La.; Southwestern, November 24, Dallas, Texas; and Northeastern, November 19, Wallingford, Conn.

Attendance at these meetings by Managing Director A. D. Hinckley should prove of great value to the local Chairmen and Secretaries of Sections and Chapters, as it has at those which he has attended this year.

Aircraft Materials Society Formed on East Coast

The Eastern Division of the Society of Aircraft Materials and Process Engineers (SAMPE), a technical society formed to meet the requirements of the space age, held its first meeting on December 19, 1958 at the Statler Hotel, Washington, D. C. The group was organized to complement a similar group previously in operation in the Southwest and on the West Coast. Temporary officers of the Society include: G. E. Holback, The Martin Co., president; R. P. Pajak, Narmco Industries, Inc., vice-president; Jay M. Stevens, Bureau of Aeronautics, secretary and John S. Thorpe, Allegheny Ludlum Steel Corp., treasurer.

GROUP attending the October 23 organization meeting of the Central Kansas Study Club.

Problems of aircraft and missile materials and processes will be the primary area of interest to the group, and quarterly technical meetings are planned to discuss these problems.

Persons interested in the SAMPE are invited to contact John S. Thorpe, Application Development Engineer — Aircraft and Missiles, Allegheny Ludlum Steel Corp., Bell Building, Tarentum, Pa.

Central Kansas Study Club Organized in Wichita

A total of 51 IES members including architects, consulting engineers, electrical contractors, utility engineers and distributors' representatives met October 23, in Wichita, Kans., to form the Central Kansas Study Club, offshoot of the Heart of America Section of IES. Their aim — to become a new Chapter of the Society.

Brooks Chassaing, Midwestern Regional Vice-President, was principal speaker at the organizational meeting, with Frank Eddins and John Krall, Chairman of the Heart of America Section, also on the program.

The meeting was held in the auditorium of the Kansas Gas & Electric Co.

Engineering Educators On Mission to India

At the request of the Indian Ministry of Scientific Research and Cultural Affairs, a committee of experts on engineering education was named by the American Society for Engineering Education to study tentative plans for a new technological institute to be built in Kanpur, India. Under a contract with the U. S. International Cooperation Administration, the group left New York in late November for a six-week stay in India, which included visits to schools and industrial plants in ten Indian cities.

Plans for all phases of the proposed new school, the physical plant as well as curricula, teaching, library and personnel, were reviewed by the American committee, which on its return to the United States will collaborate with experts on specific plans for buildings, laboratories and budgets for the Kanpur institute. Financial assistance to the new school from the U. S. International Cooperation Administration will be based, at least in part, on the recommendations of the committee.

Dr. William E. Stirton, Vice-President of the University of Michigan, was director of the mission, with Nathan W. Dougherty, former Dean of the College of Engineering, University of Tennessee, serving as deputy director. Other members of the group included: D. G. Carter, Professor Emeritus, Department of Agricultural Engineering, University of Illi-

(Continued on page 13A)

CENTRAL KANSAS Study Club. Left to right: John Krall, Chairman of the Heart of America Section, and Brooks Chassaing, Midwestern Regional V-P, with Wichita members Frank Eddins, Richard Jones and John Neylon. Mr. Neylon is Chairman of the Extension Committee.

NEW Indoor Mercury Lamp Ballasts operate in

AMBIENTS UP TO 150° F.

EXCLUSIVE WITH JEFFERSON

This new Jefferson development is specifically designed for high ambient locations such as steel mills, foundries and press rooms. It eliminates the shields, enclosures or chimneys you've needed to make a normal ambient ballast function in high temperature locations.

And remember . . . warm climates and non-air-conditioned factories can drastically cut the life of the normal ballast. You can specify *this* one, confident it will deliver *top efficiency* and *maximum life* in *any* ambient up to 150°F.

Mounting—All models have brackets for wall mounting and pry-outs which permit pendant mounting with proper accessories (accessories free if requested with order).

CATALOG NO.	APPLICATION
133-821-150	115 volt
133-823-150	230 volt
133-826-150	270 volt

Jefferson MERCURY LAMP BALLASTS

JEFFERSON ELECTRIC COMPANY, BELLWOOD, ILLINOIS

(*Continued from page* 10A)

Up to 163 Degree Spread — Up to 236,000 Candlepower: Now in

New CROUSE-HINDS Mercury Floodlights

Plus 6 Outstanding Advantages Never Before Offered in Mercury Floodlights of this Wattage

New—700 to 1,000 watt mercury floodlights with the widest beam-spread on the market . . . up to 163°. Or the brightest . . . 236,000 candlepower concentrated in a 75° solid angle! Complete with ballasted assemblies that will start lamps at —30° F. offering a further choice of three different reflectors and four different lenses (including a spun-sealed plate glass lens) to adjust the beam-spreads and candlepowers to your particular needs. All using either clear lamps for brightness, or phosphor-coated lamps for color enhancement. And all offering rear-door relamping and positive locking in open position.

Mercury Floodlighting Is Here to Stay

No other floodlight lamp approaches mercury for long burning hours . . . for economy of cost and labor in relamping. And no other mercury floodlight approaches these new MVF's for convenience of relamping, aiming, utilization factor and maintenance of output over a long period of burning. Other lights in the Crouse-Hinds range of floodlights from 250 to 700 watts provide varying beam spreads, intensities and efficiencies.

* For assistance in computing the exact fixtures, wattages and footcandles for your needs, consult your Crouse-Hinds distributor or the Illumination Department at the Factory.

CROUSE HINDS

MAIN OFFICE AND FACTORY: SYRACUSE, NEW YORK
Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.
Crouse-Hinds Instrument Company, Inc., Silver Spring, Maryland

• CONDULET® ELECTRICAL EQUIPMENT (Explosion-Proof and Conventional) • FLOODLIGHTING
• TRAFFIC CONTROL SYSTEMS • AIRPORT LIGHTING and WEATHER MEASURING EQUIPMENT •

These products are sold exclusively through electrical distributors. For application engineering help, contact one of the following offices: Atlanta Baton Rouge Birmingham Boston Buffalo Chicago Cincinnati Cleveland Corpus Christi Dallas Denver Detroit Houston Indianapolis Kansas City Los Angeles Milwaukee New Orleans New York Omaha Philadelphia Pittsburgh Portland, Ore. St. Louis St. Paul Salt Lake City San Francisco Seattle Tulsa Washington Resident Representatives: Albany Baltimore Charlotte Chattanooga Reading, Pa. Richmond, Va.

(Continued from page 13A)

(*Continued from page* 10A)

nois; J. C. Georgian, Department of Mechanical Engineering, Washington University (St. Louis); W. C. Huntington, Professor Emeritus, Department of Civil Engineering, University of Illinois; R. W. Sorensen, Professor Emeritus, Department of Electrical Engineering, California Institute of Technology and Leslie Mayberry of Chicago.

'59 Engineering Education Awards Now Under Consideration

The American Society for Engineering Education is now reviewing nominations received for four awards in engineering education to be presented at the Society's 1959 Annual Meeting in Pittsburgh, June 15-19. Honors to be bestowed include: The Lamme Award, a gold medal given annually since 1928 to honor "distinguished achievement which contributes to the advancement of engineering education;" the George Westinghouse $1000 Award made "to recognize and encourage outstanding contributions to the teaching of students of engineering;" the Vincent Bendix Award for "advancement of engineering research program in colleges and universities;" and the Curtis W. McGraw Research Award of $1000 in recognition of "early achievements by engineering college research workers under 40 years of age."

In addition to these four major awards, the Society intends to give $300 in prizes for the best papers written by ASEE members under 36 years of age. The James H. McGraw Award of $500 will be presented by the Society's Technical Institute Division to a leader in technical institute education.

The Westinghouse and Curtis McGraw Awards, reserved for younger members of the profession, are designed not only as rewards for work accomplished, but also as incentives toward further work which might be made possible by the prize funds.

Traffic Fellowships Available At Yale University

Yale University's Bureau of Highway Traffic has announced the availability of fellowships for the 1959-1960 academic year to qualified graduate engineers who are citizens of the United States and interested in entering the profession of traffic engineering. The fellowships, covering a full academic year of graduate study, are for $2,200, providing a living stipend of $1,400, disbursed at the rate of $175 per month, and $800 for the

(*Continued on page* 14A)

SCHEDULED EVENTS

January 19-23, 1959 — American Institute of Electrical Engineers (Winter General Meeting), New York, N. Y.

January 26-29, 1959 — Plant Maintenance and Engineering Show, Public Auditorium, Cleveland, Ohio.

January 27-29, 1959 — Society of Plastics Engineers, 15th Annual Technical Conference, Hotel Commodore, New York, N. Y.

February 8-14, 1959 — National Electrical Week.

February 12, 1959 — Council Meeting, Illuminating Engineering Society, New York, N. Y. Members are free to attend meetings of Council as guests.

March 1-4, 1959 — Second National Lighting Exposition, New York Coliseum, New York, N. Y.

March 1-4, 1959 — National Electric Sign Association, Morrison Hotel, Chicago, Ill.

March 9-12, 1959 — Edison Electric Institute Sales Conference, Edgewater Beach Hotel, Chicago, Ill.

March 24-26, 1959 — Fifth Biennial Chicago Electrical Industry Show, Hotel Sherman, Chicago, Ill.

April 1, 1959 — Inter-Society Color Council (28th Annual Meeting), Statler-Hilton Hotel, New York, N. Y.

April 9-10, 1959—East Central Regional Conference, Lord Baltimore Hotel, Baltimore, Md.

April 22, 1959 — Council Meeting, Illuminating Engineering Society, Asheville, N. C. Members are free to attend meetings of Council as guests.

April 22-24, 1959—South Central and Southeastern Regional Conference, Grove Park Inn, Asheville, N. C.

May 3-8, 1959 — Society of Motion Picture and Television Engineers, The Fontainbleau, Miami Beach, Fla.

May 4-5, 1959 — Southwestern Regional Conference, Shamrock-Hilton Hotel, Houston, Tex.

May 6-8, 1959 — Midwestern Regional Conference, Pere Marquette Hotel, Peoria, Ill.

May 11-12, 1959 — Inter-Mountain Regional Conference, Continental Hotel, Denver, Colo.

May 20-21, 1959 — Building Research Institute Conference on Building Illumination, Statler-Hilton Hotel, Cleveland, Ohio.

May 24-29, 1959 — National Association of Electrical Distributors (51st Annual Convention), Conrad Hilton Hotel, Chicago, Ill.

May 26-30, 1959 — Pacific Northwest Regional Conference, Banff Springs Hotel, Banff, Alta.

June 4-5, 1959 — Northeastern Regional Conference, Curtis Hotel, Lenox, Mass.

June 11-12, 1959 — Canadian Regional Conference, Chateau Laurier, Ottawa, Ont.

June 18, 1959 — Council Meeting, Illuminating Engineering Society, New York, N. Y. Members are free to attend meetings of Council as guests.

June 22-23, 1959 — Great Lakes Regional Conference, Lafayette Hotel, Buffalo, N. Y.

June 22-26, 1959 — American Institute of Electrical Engineers, Summer and Pacific General Meeting, Seattle, Wash.

October 5-10, 1959 — Society of Motion Picture and Television Engineers, Hotel Statler, New York, N. Y.

October 12-14, 1959 — National Electronics Conference, Inc., Hotel Sherman, Chicago, Ill.

October 12-16, 1959 — American Institute of Electrical Engineers, Fall General Meeting, Chicago, Ill.

November 2-5, 1959 — Eleventh Exposition of the Air-Conditioning and Refrigeration Industry, Convention Hall, Atlantic City, N. J.

November 9-13, 1959 — National Electrical Manufacturers Association, Traymore Hotel, Atlantic City, N. J.

I.E.S. National Technical Conferences

1959 — September 7-11 — Hotels Fairmont and Mark Hopkins, San Francisco, California

1960 — September 11-16 — Penn Sheraton Hotel, Pittsburgh, Pennsylvania

1961 — September 24-29 — Chase Park Plaza Hotel, St. Louis, Missouri

1962 — September 9-14 — Statler-Hilton Hotel, Dallas, Texas

(Continued from page 13A)

year's tuition. The awards are made possible through grants to the Bureau from the Automotive Safety Foundation, the Esso Safety Foundation, The Liberty Mutual Insurance Co. and the James S. Kemper Foundation.

Tuition scholarships are also available for municipal and state highway engineers who will also receive financial aid from their employers while undertaking graduate study.

Courses offered in the highway traffic program include traffic characteristics and measurements, traffic regulations and control devices, highway planning, highway location and geometric design, and highway administration and finance.

Applications for admission and further information on the fellowships are available from Fred W. Hurd, Director, Bureau of Highway Traffic, Yale University, Strathcona Hall, New Haven, Conn.

ABOUT PEOPLE

Effective November 15, the San Francisco firm formerly known as Fluorescent Fixtures of California became All-Brite Fluorescent Fixtures, Inc., according to an announcement by **E. O. Anders,** newly-elected Chairman of the Board. Mr. Anders, the founder of the All-Brite line, and head of Fluorescent Fixtures of California, was succeeded in the presidency by **Charles D. Buchanan,** former vice-president. Mr. Buchanan will also serve as general sales manager for the organization. In another announcement by All-Brite, the promotion of **Fred J. Bertolone** to San Francisco District Sales Manager was made known.

Alan R. Cripe, former Director of Design for the Chesapeake and Ohio Railway Co., was named Director of Product Planning for the John C. Virden Co., Cleveland, effective December 1. In addition to his duties with Virden, Mr. Cripe will also be available for a limited amount of consulting in the fields of industrial design, transportation equipment and architecture.

The former Los Angeles operation of Globe Lighting Products, Inc. is now an autonomous corporation operating under the name of Globe Illumination Co., it was announced by **Max Rosenblatt,** president of the Los Angeles firm. According to Mr. Rosenblatt, personnel will remain unchanged, national distribution will continue through existing channels and no policy changes are contemplated.

Art Mark Associates, Inc. New York, N. Y., headed by **Arthur Levinson** and **Mark Schaefer,** will serve as exclusive export representative for Supro Lux Manufacturing Co., Inc., Bronx, N. Y., according to a recent announcement.

Raymond J. Stefany has been appointed Manager of Aviation Sales by the Westinghouse Electric Corp. Lamp Division. In his new post, Mr. Stefany will be responsible for the sale of lighting products and systems relating to airport approach lighting, runway systems, aircraft identification and directional beam systems. His offices will be at the Lamp Division headquarters in Bloomfield, N J.

Progress Manufacturing Co., Inc., Philadelphia residential fixture manufacturer, has announced appointments to two newly-created marketing positions. **Will**

(Continued on page 16A)

From the desk of the President . . .

One gigantic task which your Society has been undertaking over the past several years has been the preparation for publishing and distributing a new *IES Lighting Handbook,* this one the Third Edition. Probably you have heard rumblings through your Society contacts, or as one of the 500 members of 34 Technical Committees involved, of the size and scope of this over-all *Handbook* project. For at least the past two years, in addition to the text preparation of the Third Edition by the Technical Office, the Advertising and Promotion section of Headquarters has devoted a great deal of time to planning and preparing for the big distribution project ahead.

Within the past two months, you (and nearly 75,000 others, IES members and non-members) have received the announcement of this big new Third Edition and an opportunity to buy your copy *before publication* at a greatly reduced price. Over 5200 of the new *Handbooks* have already been ordered, and a large number of return cards are being received every day. Obviously, this money-saving offer could not be made if your Officers had not decided to print as many books as possible and distribute them as quickly as possible, to give each IES member at least one copy of the new *Handbook* at the very lowest price. But there is also a much more important reason.

No IES Committee report is worth anything, except to the particular committee involved, while still in the minds or notes of the Committee members. It is only upon publication of any report that the basic IES objective of "the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto" is satisfied. The *Handbook,* which brings together in one volume all of the lighting information garnered over many years, is the classic example. It has been referred to as the "bible" of the lighting industry; "the highest authority on lighting" and other glowing terms. So with this new Third Edition being published in March, your Society not only has notified every IES member, but also has sent the announcement far and wide beyond IES membership to further fulfill our "dissemination" and education responsibility.

In addition to distributing the *Handbook,* the IES Advertising and Sales Promotion section has the year-in year-out responsibility for promotion and sale of advertising space in ILLUMINATING ENGINEERING and the sale of 50 or so IES publications developed by the Technical Committees. Thus, if you or your company wants to advertise in IE; buy or order IES Publications; or ask questions about these publications, Clayt Ellis, our Advertising and Promotion Manager, or his assistant, Sally Philibn, are the ones who will handle your problem at Headquarters.

The IES Publications program has grown in the past ten years to be our largest single source of financial support for the Society's program and ILLUMINATING ENGINEERING has achieved national recognition in the trade and technical magazine field for the quality of its reporting. We can well be proud of our official journal, as we can of our other publications and of the *IES Lighting Handbook,* the "last word" in lighting information and authority.

By the way, be sure you order your member copy of the new Third Edition as soon as possible. Take advantage of your special one-copy-per-member price. In this issue of IE you'll find a descriptive brochure and stamped order card. Be sure to use it.

GEORGE J. TAYLOR
IES President

ROTUBA'S LIGHTING DATA REPORT 12-58

LIGHTING OF ROCKEFELLER CENTER STORE WINDOWS

LIGHTING OBJECTIVE: To improve the lighting of the display windows by replacing the old luminous plastic material of the double-track ceiling with a more efficient construction plus a more dimensionally stable plastic material for A) uniform, glareless light, B) easier maintenance and C) more attractive general appearance.

These double display windows of Parker & Battersby Men's Camera and Cutlery Store face the interior main floor lobby of the RCA Building of Rockefeller Center, New York.

Major advantages of the Extru-Lite Installation — no glare, uniform light distribution, easy maintenance. Notice how clearly name of store stands out on plate.

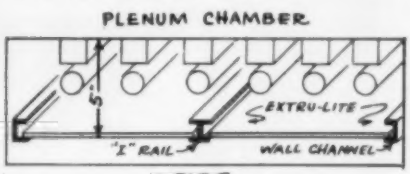


FIG. I

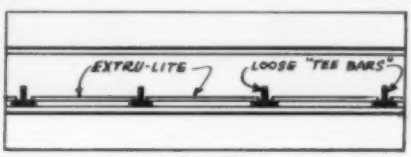


FIG. II

GENERAL INFORMATION: The store owner first realized with a shock that his lighting was deficient, when he could barely distinguish his name on the bronze plaque at window base. This made him aware that his merchandise, too, was poorly illuminated.

Since these windows require a high degree of visibility for the successful merchandising of all the highly detailed items therein, he knew his light shielding was antiquated.

The old ceiling was difficult to remove and infrequently cleaned and the collected dust and grime reduced the illumination even more. The new ceiling was designed so panel components fit snugly, yet could be easily removed for maintenance.

INSTALLATION: Certain parts of the former structure had to be retained; such as, the shallow (abt. 5" deep) plenum chamber, the number of lamps, front and back Wall Channels and the Central "I" Beam (See Fig. 1). Free "Tee" Bars were placed resting on the Wall Channel and reaching across to rest on the Central "I" Beam. (See Fig. 2).

In each "Tee" Bar partition thus formed, sheet of EXTRU-LITE®*, plastic prismatic low-brightness panels cut to size were placed in a regular pattern, with the smooth side of the Extru-Lite facing the lamps. As each "Tee" Bar was inserted, a panel of Extru-Lite was manipulated into place, fitting tightly enough to avoid any dislodgement or slippage.

RESULT: An increase in illumination by approximately 72% — without glare. The Acrylic Extru-Lite (in this installation made of Plexiglas®†) assures greater permanence of color, dimensional stability and eliminates warpage. Nor does Extru-Lite change the true color of light. This fact results in good color quality on the merchandise, showing it up to better advantage. The eye-appealing attention achieved through the increased, superior illumination results in increased traffic for the store.

***That's why we say:* THE BEST BUY IN SIGHT — FIXTURES USING EXTRU-LITE.**

*Available in both Polystyrene or Acrylic.
†Rohm-Haas

RIGID PLASTIC EXTRUSIONS

THE ROTUBA EXTRUDERS, INC.
A DIVISION OF WALJOHN PLASTICS, Inc.
MAKERS OF PLASTIC EXTRUSIONS FOR INDUSTRY
437 88th STREET, BROOKLYN 9, NEW YORK • SHORE ROAD 8-5458

Lighting Equipment designed by Herbert Hoffman, Lighting Consultant, and installed by Condi-Lite Corporation, both of 889-891 Broadway, New York 3, N. Y.

(*Continued from page* 14A)

Turner, former district sales manager of the southwestern division, has been named Director of Sales, and **William T. Steele,** previously sales manager of the fans and special products division, will assume the post of National Sales Manager.

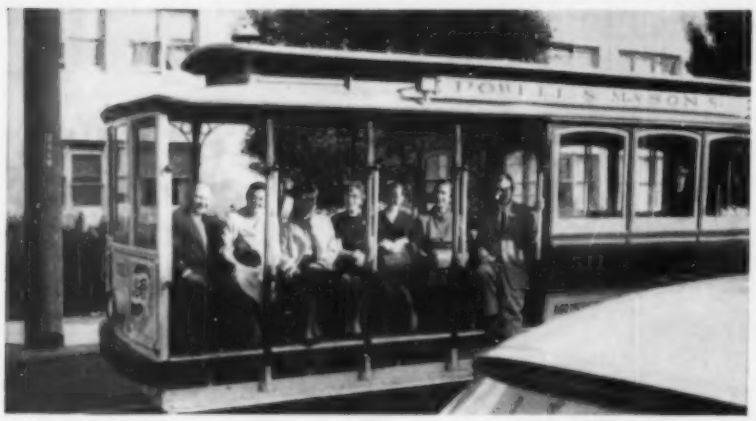
Rose M. Coakley has been appointed Consultant in Lighting for the Moe Light Division of Thomas Industries, Inc., Louisville, Ky. For the past four years, Miss Coakley had been associated with the General Electric Co. Large Lamp Department as a residential lighting equipment specialist, and prior to that was with the Toledo Edison Co.

Beverly Bunn, former lighting specialist with the Westinghouse Electric Supply Co. in Milwaukee, Wis., has been named as the new Holophane Co., Inc. representative in the St. Louis area.

Granville Berry, Coventry, England, has been elected President of the British Association of Public Lighting Engineers, according to information recently received here.

Deaths

Hilton P. M. Carter, Montreal Section.
Frank S. Donahue, St. Louis Section.
Leo J. Heenan, Michigan Section.



Picture Yourself in this Situation

By San Francisco's famous cable car, planners for women's entertainment at the 1959 National Technical Conference ride to a meeting. Left to right: Guy de Leuze, chairman, Mary Duhme, Margaret Walsh, Ramona Trosper, Alice Sawyier, Carol Barnes and Mark Jensen, vice-chairman.

Wives who attend the National Technical Conference in San Francisco next September will probably enjoy their visit far more than their busy husbands. For they, at least, will be able to participate in the many entertainment features being planned for them by the ladies committee of the general conference committee, Guy de Leuze, chairman.

While their husbands are busy at technical sessions, the ladies and their families will have the choice of a number of side trips. Anticipating perfect fall weather, customary in the San Francisco Bay area, a sight-seeing boat trip on the bay is being planned. This will include a box lunch picnic on Angel Island, a seldom-visited island in the vast bay crossed by the famed Golden Gate Bridge.

How California wines are produced will be seen and samples dispensed, on a tour to the wine country of Napa and Sonoma counties. The ancient wineries have been producing for over 100 years. Original vine stock was imported from France and Germany.

A Chinese luncheon and a fashion show at the colorful Johnnie Kan restaurant in San Francisco's famous Chinatown, shopping tours and sight-seeing trips have all been arranged.

For those who play golf, this, too, is available at the Orinda Country Club across the bay and through the Oakland Hills. After the golf play there will be an outdoor barbecue and evening of fun.

BOOKS AND PAMPHLETS

Engineering Careers in Canada, 1958-1959 Edition, published by The Engineering Institute of Canada, 2050 Mansfield St., Montreal, Que., 106 pp.

Descriptive summaries of 20 engineering fields, from agricultural engineering through teaching and research in universities are contained in this guide designed especially for engineering students. In addition to the above, the booklet also contains "Information Service Cards" which students can send to the EIC for further information and contact with possible employers.

Technical Societies Guide, published by Industrial Publicity Association, Technical Societies Committee, 41 East 42nd St., New York 17, N. Y. 32 pp., $3.

Prepared in cooperation with 36 technical societies, this handy reference manual contains procedures for presentation and preparation of papers for technical societies and trade associations. Data on other aspects of the societies, such as membership structure, number of members, principal meeting dates, area of interest, policies regarding preprints, reprints, publication and publicity are also included. The last five pages of the booklet are devoted to a special guide for authors on fundamentals of oral presentation, preparation of visual aids, and preparation of manuscripts for submission to editors. Copies are available from the IPA Technical Societies Committee.

Processing of Thermoplastic Materials, published by Reinhold Publishing Corp., 752 pp., $14.40 to Society of Plastics Engineers members, $18.00 to nonmembers.

Compiled with the aid of 19 technical authorities and supported by 14 plastics firms and universities, this is a definitive handbook covering all aspects of thermoplastics processing. It includes information on engineering problems involved in extrusion, injection molding, calendering and other thermoplastics processing operations, as well as fundamentals of flow behavior, heat transfer, thermodynamics, mixing and dispersing. *Processing of Thermoplastic Materials* is Volume II in the SPE Plastics Engineering Series, and is available, at the prices quoted above, from the Society of Plastics Engineers, Inc., 65 Prospect St., Stamford, Conn.

Eyes, Our Windows to the World, published by Better Light Better Sight

(*Continued on page* 18A)

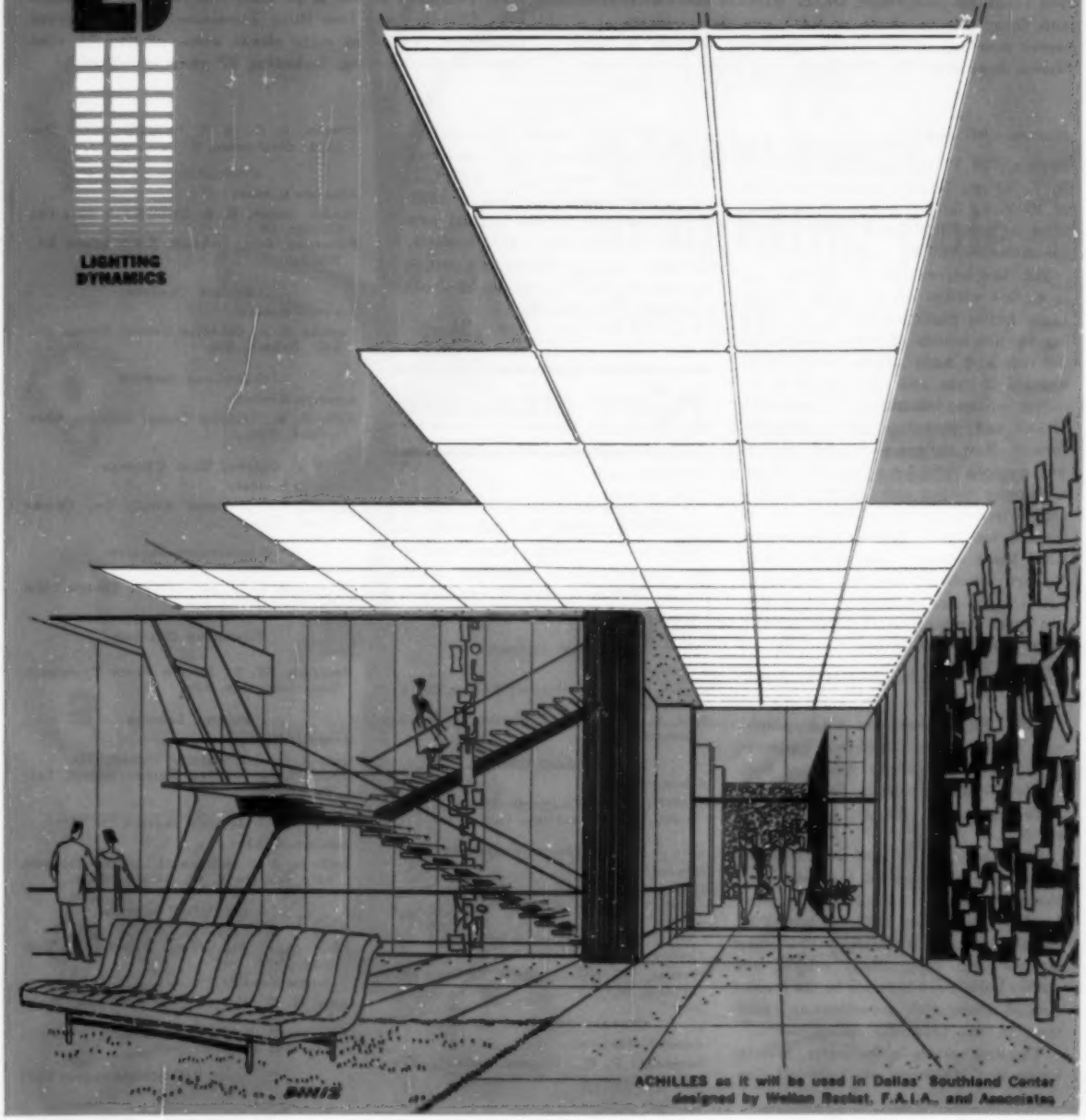
problem

An easily maintained, integrated fixture was needed for Welton Becket's dramatic "squares of light" ceiling in the lobbies and offices of Southland Life's spectacular 42-story Southland Center in Dallas.

solution

ACHILLES by Lighting Dynamics was specified for the lobby... and it's companion Apollo was used in the offices throughout the center. Achilles is a highly versatile fixture series ideal for this demountable acoustical ceiling—just as it is for countless other ceiling suspension systems. It's quickly installed with a drop-in installation and has easy maintenance with press-to-open catches and hook-on hinges. Durable, Bonderized and electro-static, high-reflectance finishes... FOR MORE COMPLETE INFORMATION, call your Lighting Dynamics representative, or write to Lighting Dynamics, 802 West Whittier Blvd., Whittier, California or Lighting Dynamics, 8700 Ambassador Row, Dallas, Texas.

LIGHTING DYNAMICS



ACHILLES as it will be used in Dallas' Southland Center designed by Welton Becket, F.A.I.A., and Associates

REPORT on the new Recommended Levels of Illumination from the researcher, Dr. H. Richard Blackwell, (second from left in photo at left) was the program at a recent meeting of the Tennessee Valley Section of IES. Shown here with Dr. Blackwell are, from left to right, Don Harris, Section Chairman; (Dr. Blackwell); Terrill Hall, President of the local American Institute of Architects Chapter; and Don Bills, Tennessee Valley Program Chairman. Photo at right shows some of the 75 who attended the meeting, including 32 guest architects.

(Continued from page 16A)

Bureau, 750 Third Ave., New York 17, N. Y. 32 pp., 10 cents each in quantities of 1000 and less; 8 cents each in quantities of 1000-5000 and 6 cents each in quantities over 5000.

This booklet, written in lay-language, is a new edition of an earlier Better Light Better Sight publication on lighting and the science of seeing. It retains the title and many of the basic fundamentals of light and sight found in the earlier edition, but has been completely revised and printed in an entirely new format. How the eye works, how we see, why we need light for seeing, how to get the proper quality and quantity of light are all included in the booklet, as well as the new residential lighting recommendations based on the research of Dr. H. Richard Blackwell, as they were published in the August issue of ILLUMINATING ENGINEERING. Orders for the booklet, form number B-564, should be sent directly to BLBS Bureau.

1957 Supplement to Bibliography and Abstracts on Electrical Contacts, STP 56-L, published by American Society for Testing Materials, 1916 Race St., Philadelphia, Pa. 54 pp., paper-bound, $1.75.

With the publication of this bibliography covering papers on the subject of electrical contacts published from October 1956 to October 1957, the total number of references contained in this series is now over 2600. Both subject and author indices are included in the present booklet, along with corrections and additions for the 1934-1955 period.

The first volume in the series, *Bibliography and Abstracts on Electrical Contacts*, STP 56-G, covers the period from 1835 to 1951, and is a cloth-bound volume of 225 pages. Supplements 56 H, I, J, K and L (the present one) are for 1953 to 1957. List price for the original volume and five supplements is $12; however, if the entire set is purchased as a unit, it is available for $10. Copies can be obtained from ASTM headquarters.

NEW MEMBERS

At the meeting of the I.E.S. Council on December 11, 1958, the following were elected to membership. Names marked * are transfers from Associate Member Grade. Names marked ** are transfers from Student Member Grade.

ALAMO SECTION

Associate Members:

Kogian, G. L., Jr., Graybar Electric Co., San Antonio, Texas.

Rust, R. D., Electrical Distributing Co., San Antonio, Texas.

ARROWHEAD CHAPTER

Associate Member:

Goddard, J. R., Tri-County Electrical Wholesalers, San Bernardino, Calif.

BRITISH COLUMBIA SECTION

Member:

Coldwell, C. R., Van Horne Electric Supply, Ltd., Vancouver, B. C.

CENTRAL ILLINOIS CHAPTER

Member:

*Fernau, R. M., Day-Brite Lighting, Inc., Peoria, Ill.

CENTRAL NEW YORK SECTION

Associate Members:

Donabella, J. G., Niagara Mohawk Power Corp., Syracuse, N. Y.

Winters, D. R., N. Y. State Electric & Gas Corp., Binghamton, N. Y.

CHICAGO SECTION

Associate Members:

Bragen, Joseph, R. R. Donnelley & Sons Co., Chicago, Ill.

Fetherston, Lois, Architect, North Adams Rd., Hinsdale, Ill.

CHINOOK CHAPTER

Associate Member:

Parsons, G. A., Canadian General Electric Co., Ltd., Calgary, Alta.

CLEVELAND SECTION

Associate Member:

Mills, S. M., Lighting Design Services, Chesterland, Ohio.

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(Continued on page 21A)

from UNION METAL...

a "new twist" in lighting pole design

Call it tree form, futuristic, revolutionary or just plain different... it's typical of the *new* thinking in design, development and manufacture offered by Union Metal... world pioneer and leader in the manufacture of lighting poles.

The

UNION METAL

Manufacturing Company

Canton 5, Ohio

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Created for Chicago's State Street to replace Union Metal poles installed in 1926.

PROTECTED LIGHTING!

VAPOR TIGHT CRAFT LITE

SO RUGGED YOU CAN JUMP ON IT!

CRAFT-LITE IS:

VERSATILE—beyond ANY OTHER FIXTURES—truly the **EVERYWHERE** light, indoors, outdoors, wet or dry.

PROVED—by ten years of LEADERSHIP as **the fixture for toughest applications** requiring **more** than ordinary protection.

RUGGED—in its construction to guard against **all** customary hazards to lighting.

EFFICIENT—MAXIMUM GLARE-FREE LIGHTING UNDER ALL CONDITIONS, in truly modern, functional design.

SAFE—beyond ANY OTHER LIGHTING!

ALL THIS—and—A BONUS OF BEAUTY, TOO . . . with CRAFT-LITE.

WHAT'S YOUR TOUGHEST LIGHTING PROBLEM?

WHAT'S YOUR TOUGHEST LIGHTING PROBLEM? WRITE US TODAY FOR THE **CRAFT-LITE ANSWER TO THAT PROBLEM!**

PARAMOUNT INDUSTRIES, Inc.

G-1080 BALLENGER ROAD FLINT 4, MICHIGAN

MANUFACTURED IN CANADA BY C&M PRODUCTS LIMITED, SCARBOROUGH, ONTARIO

(*Continued from page* 18A)

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Benjamin, K. U., Shelley Electric, Inc., Wichita, Kans.
Cocking, M. P., Graybar Electric, Wichita, Kans.
Eagan, W. D., Curt H. Conrad Co., Kansas City, Mo.
English, B. L., Finlay Engineering College, Kansas City, Mo.
Gore, J. K., Westinghouse Electric Supply Co., Wichita, Kans.
Henderson, G. J., Carl Green & Associates, Wichita, Kans.
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Lovell, R. C., Westinghouse Electric Corp., Wichita, Kans.
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Phillips, R. E., Shelley Electric, Inc., Wichita, Kans.
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Cadwallader, W. P., Charles T. Main, Inc., Boston, Mass.
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Reinhardt, F. W., Fall River Electric Light Co., Fall River, Mass.
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Murphy, J. L., Chauvin Electric Co., Albuquerque, N. M.
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Kennedy, G. J., Day-Brite Lighting, Inc., New York, N. Y.
Lowe, D. R., General Electric Co., New York, N. Y.
Marshall, R. G., Rohm & Haas Co., New York, N. Y.
Meyer, H. R., National Lighting Expositions, New York, N. Y.

(*Continued on page* 42A)

SEEN at the organizational meeting of the National Lighting Bureau's Executive Committee in New York's St. Regis Hotel are, seated l. to r., J. R. Steel, W. W. Booth, A. W. Hooper, B. F. Benning, Chairman-Elect A. F. Wakefield, Don Julien, George Roscoe, Morton Silverberg. Standing l. to r.: Garlan Morse, C. E. Erb, J. G. Waddell, W. M. Freudigman, R. G. Slauer, Ed Themak, H. E. Cliff, Franklyn Dickinson and L. C. Messick, National Lighting Bureau head.

January 30 — Last Chance for Submitting 1959 Conference Paper Outlines

January 30, 1959 is the deadline set by the Papers Committee of IES for submission of outlines of proposed papers for the 1959 National Technical Conference to be held in San Francisco. Outlines of the proposed papers should be mailed, in triplicate, to:

Floyd W. Sell, Chairman, IES Papers Committee
c/o The Detroit Edison Company
2000 Second Avenue
Detroit 26, Michigan

A Day-Brite job throughout . . . CONSUMERS POWER CO., Lansing, Mich. KENNETH C. BLACK, *Architect;* E. ROGER HEWITT, *Mechanical and Electrical Engineer;* LANSING ELECTRIC MOTORS, *Electrical Contractors.*

The tough lighting jobs go to DAY-BRITE

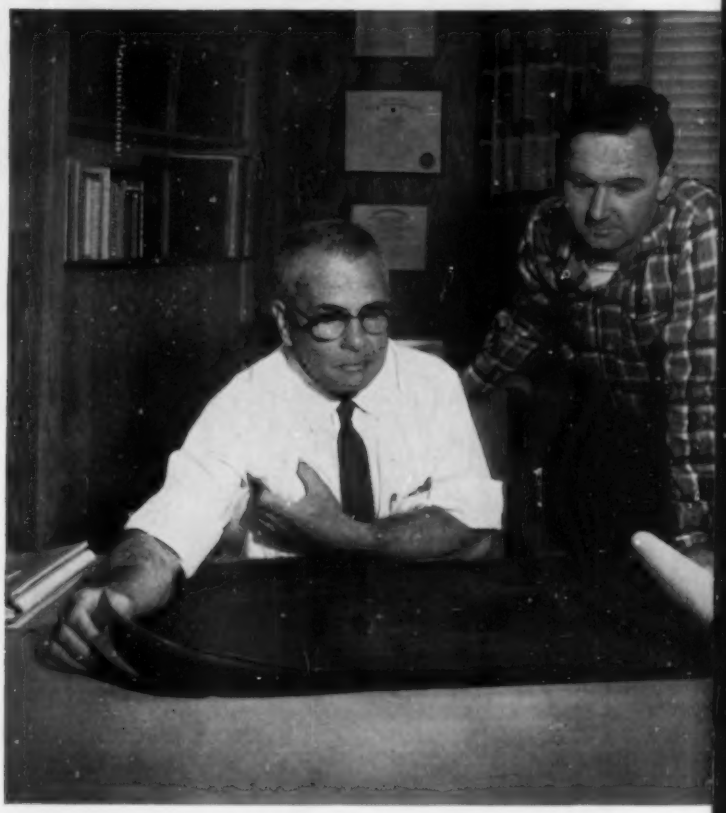
Lighting the new Lansing home of Consumers Power Co. might have been complicated by the wide variety of *area* and *ceiling* functions.

Achieving the desired quality and quantity of illumination required by area function was no problem. 26 different kinds of Day-Brite fixtures were specified to meet every lighting need.

Mechanical planning and fixture installation were simplified, too, because Day-Brite equipment is designed for smooth integration with standard ceiling assemblies. Day-Brite *pioneered* and *introduced* today's widely accepted Ceiling Indexing System.

Most good architects, engineers and contractors think of Day-Brite *first* when lighting problems arise. Next time we can be of service to you, call your Day-Brite representative listed in the Yellow Pages.

DAY-BRITE . . . the Engineer's Choice



Consulting Engineer E. ROGER HEWITT (left) and WILLIAM TROMBLEY, Electrical Designer

How important is service?

Here's what Day-Brite service means to Roger Hewitt:

"Our fixture specifications are based upon a continuing analysis of all lighting fixtures. Design features, durability, assembly and installation procedures are carefully evaluated. Our specification requirements are rigid, but Day-Brite equipment never fails to meet them . . . and the price is right.

"As important as any of these requirements, however, is the service provided by the manufacturer. Here, too, Day-Brite is outstanding. On the Consumers Power Co. project, for example, a Day-Brite engineer came up to consult with us on the job, and was extremely helpful.

"I speak from experience when I say that the services performed by Day-Brite personnel—both at the factory and in the field—leave no cause for complaint."

SEE OUR CATALOG IN SWEET'S ARCHITECTURAL FILE OR WRITE FOR COPY

DECIDEDLY BETTER
DAY-BRITE
LIGHTING FIXTURES

Day-Brite Lighting, Inc.
6258 N. Broadway, St. Louis 15, Mo.
Day-Brite Lighting, Inc. of Calif.
530 Martin Ave., Santa Clara, Calif.

Z-440 ©Day-Brite Lighting, Inc. 1958

NATION'S LARGEST MANUFACTURER OF COMMERCIAL AND INDUSTRIAL LIGHTING EQUIPMENT

Mechanical planning and fixture installation were representative listed in the Yellow Pages.

Constitution Hall, Washington, D.C.

(DAUGHTERS OF THE AMERICAN REVOLUTION)

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BERNARD LYON FRISHMAN & ASSOCIATES, *Architects* • C. WARREN BOGAN & ASSOCIATES, *Consulting Engineers*

When it comes to lighting large and lofty interiors the Rambusch Downlite has no equal. It is efficient, safe, economical, simple to maintain, glare shielded and guaranteed to produce the promised results. • There are 100 Rambusch lighting representatives in the country—one of them is near you and anxious to serve you.

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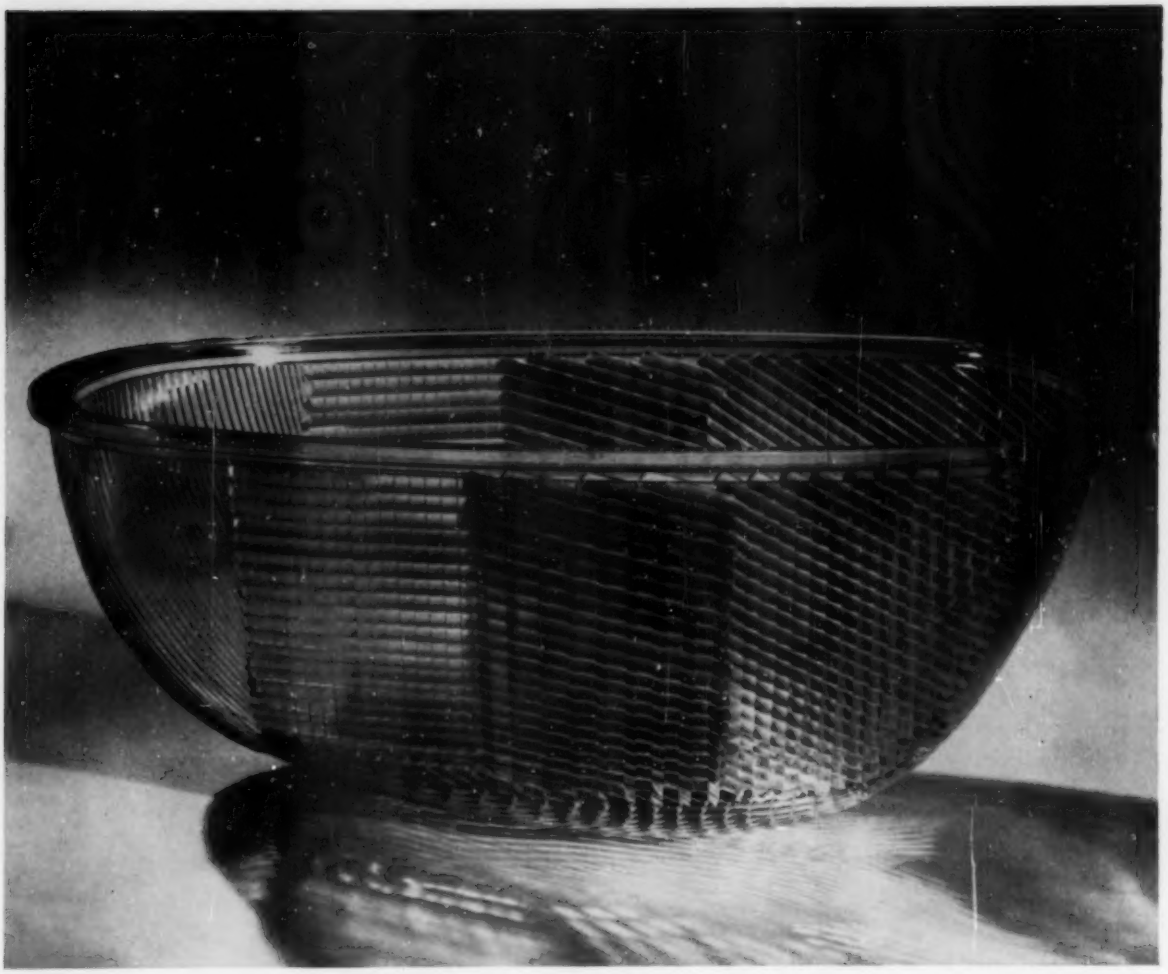
40 WEST 13th STREET, NEW YORK 11, N. Y.



NEW PYREX® REFRACTOR

designed by Corning for Westinghouse withstands heat from a 1000-watt lamp!

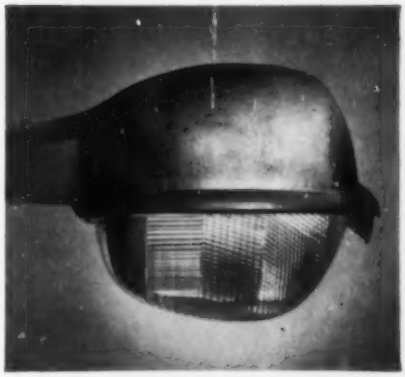
The problem: to design a street light refractor that . . .

1. Meets critical optical specifications.
2. Would withstand the temperatures generated by 1000-watt lamps.

The solution is pictured above — a new PYREX refractor for the Westinghouse OV-35 luminaire . . . designed by Corning's Lighting Development Laboratory and manufactured of PYREX brand heat-resisting glass No. 7740.

This PYREX refractor won't crack or shatter—withstands the most severe thermal shock. And it's *tough*—less chance of breakage during storms or as a result of vandalism.

Solving problems like these is an old habit of Corning. Perhaps PYREX glassware is the answer to *your* problem for high-wattage lighting. If so, drop us a line at 61 Crystal Street, Corning, New York.



CORNING GLASS WORKS

CORNING MEANS RESEARCH IN GLASS

Lighting the way to *safer* safety records, Sylvania Silver-White lamps deliver up to 22% more lumens than other types of color-improved Mercury lamps

. . . with Sylvania *Ruggedized* Mercury Lamps

Powerful in every way, Sylvania clear and Silver-White Ruggedized Mercury Lamps are specially designed with features to meet all your highway and street lighting requirements . . . reduce your maintenance costs. For example: **Ruggedized glass** protects against moisture and condensation, moisture-laden or humid atmospheres, thermal shock.

Increased lumen output. Recent phosphor improvements boost our Silver-White Phosphor-Coated SH-1 lamp from 23,000 lumens in 400 watts to 25,000 lumens—the most efficient commercial mercury lamp (62.5 lumens per watt) available today.

9000 hours average usable life. You get the equivalent of two years' street lighting service. Built for long life and high lumen maintenance, these lamps have increased from 7000 to 9000 usable hours.

Ruggedized construction throughout. Arc tube supports are specifically designed to resist and protect the lamp from destructive shocks and vibrations.

Sylvania's exclusive life-recording bases permit you to keep a convenient permanent check on lamp performance.

Guaranteed performance. Free exchange on any lamps which burn out during the first 1000 hours.

For complete information about the Sylvania Ruggedized line of Mercury lamps, call your local representative or write:

SYLVANIA LIGHTING PRODUCTS
Division of Sylvania Electric Products Inc.
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In Canada: Sylvania Electric (Canada) Ltd.
P. O. Box 1190, Station "O", Montreal 9

A complete line of Ruggedized Lamps
400-watt, 425-watt, 700-watt and 1000-watt sizes.
Silver-White (Kolor-Keyed), Clear, and Color-Improved types.
Lumen Outputs from 20,000 to 62,000.

SYLVANIA Lighting Products

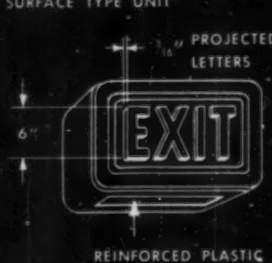
make light a better tool for safety

LIGHTING • TELEVISION • RADIO • ELECTRONICS • PHOTOGRAPHY • ATOMIC ENERGY • CHEMISTRY-METALLURGY

after-glow

NEW, PROJECTED LETTER

FLUORESCENT EXIT UNITS by PERFECLITE



Check These Superior Features:

Phosphorescent Lucite panel gives ½ hour after-glow should the circuit become dead. 6" projected letters. Available in models for all surface type as well as recessed installations. Mounted from top, back, side or from a pendant. Surface models are also available for either single or double face use. Pivot hinged, die formed 20 ga. steel frames for easy servicing. Surface type boxes are made of 18 ga. press drawn steel, ½" KO's top and side. Recessed boxes are of 20 ga. press drawn steel, six ½" KO's.

Lucite faces available in 4 color combinations — with or without arrows. Completely wired for two T-5 6-watt lamps, 118-V. AC ballasts. Also available for use in 277-V. systems.

You reduce installation costs, make every building safer when you select Perfeclite unbreakable projected letter fluorescent exit signs. For further information, mail the attached coupon today!

PERFECLITE PRODUCTS — THE MARK OF LIGHTING SERVICE

Units are Underwriters Laboratories, Inc., approved, and comply with National Electrical Code.

Please send me the Perfeclite Data Folder EX-58 C.

NAME _____

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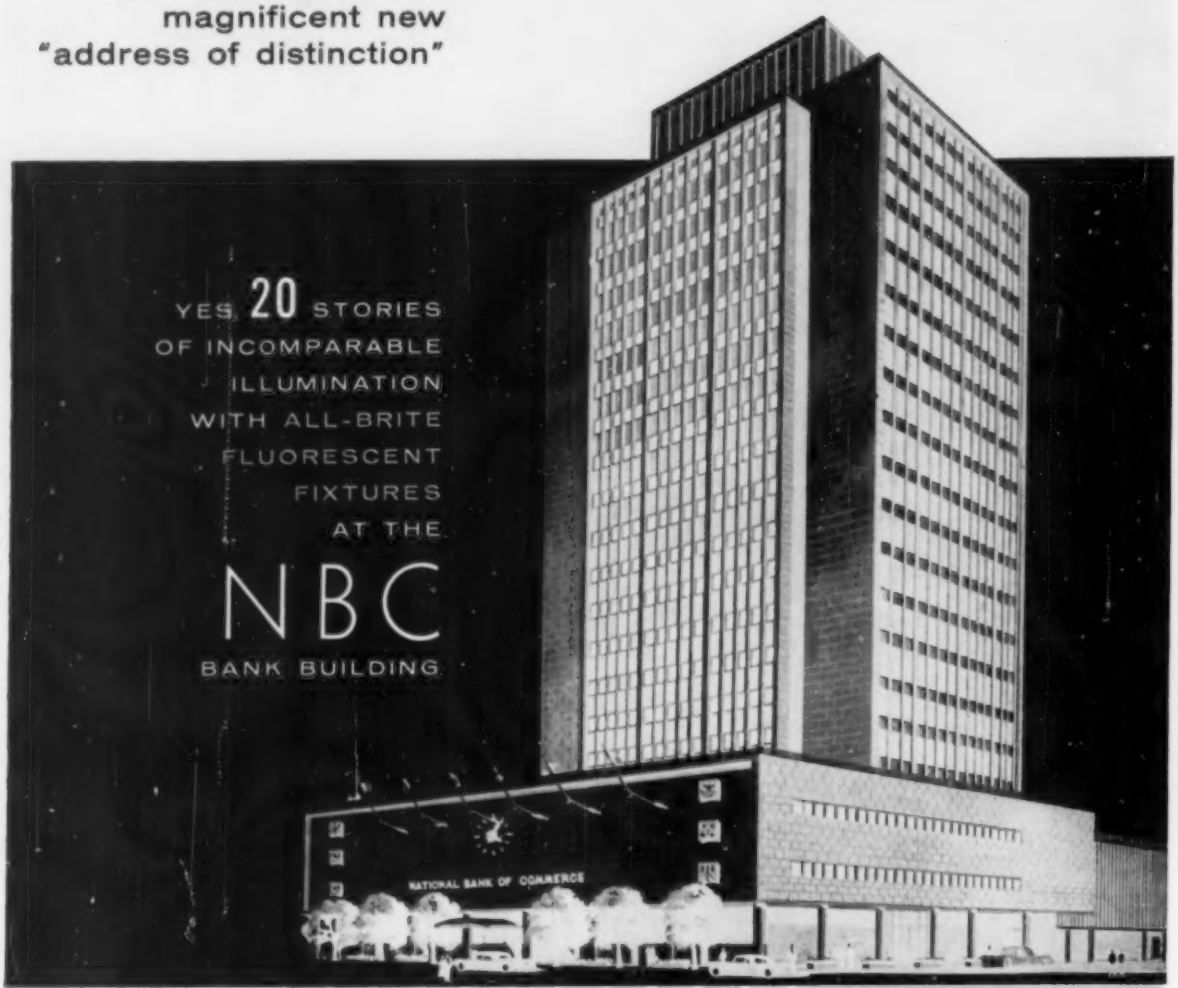
THE PERFECLITE COMPANY

1457 EAST 40th STREET • CLEVELAND 3, OHIO

ALL-BRITE
lights San Antonio's
magnificent new
"address of distinction"



Architect: Kenneth Franzheim, Houston. Associate architects: Atlee B. and Robert M. Ayres, San Antonio. Electrical contractor: Paul Wright Electrical Co., San Antonio. Consulting electrical engineer: Dale S. Cooper, Houston.

NEARLY 2000 PEOPLE WORK BETTER, FEEL BETTER, SEE BETTER

All-Brite Constellaire fixtures, installed thruout the new National Bank of Commerce Building, feature LIGHT-STABILIZED injection-molded polystyrene plastic louvers. Result: comfortable 45° shielding combined with beautiful design.

All-Brite
LIGHT OF AMERICAN COMMERCE

how can we help with YOUR lighting problems? Please ask for catalog.

ALL-BRITE FLUORESCENT FIXTURES, INC.
352 SHAW ROAD, SOUTH SAN FRANCISCO, CALIF.

PLANTS ALSO IN LOS ANGELES, SEATTLE, AND VANCOUVER, B. C.
REPRESENTATIVES THRUOUT THE UNITED STATES AND CANADA

Positive
CONNECT
and DISCONNECT
with
QUAD
EASY
TACH
IN SECONDS
TO CONNECT
TURN 2
1 UP
1. Simply push the pronged socket up into the cast hood.
2. Turn clockwise and you have instant mechanical and electrical connection.
DISCONNECT JUST AS EASILY
3 TURN
OFF 4
2 UP
1 TURN
1. Grasp the reflector lightly and turn counter-clockwise, 2. A slight pressure upward unlocks the socket and . . . 3. then rotating the reflector counter-clockwise, 4. a slight downward motion removes the reflector.
QUAD

QUADRANGLE
RLM

AMERICA'S MOST COMPLETE INCANDESCENT RLM LINE

QUAD EASY-TACH is an entirely different, simple to wire, terminal base and detachable reflector lamp holder assembly. The hood has an exclusive spring-action that permits easy, fool-proof, snap-on and snap-off of any QUAD socket type reflector.

It is mechanically designed so that the socket makes positive electrical contact with balanced pressure. Its switch-like action prevents electrical arcing and re-lighting when servicing or interchanging reflectors.

EASY-TACH disconnect sockets fit nine different standard QUAD reflector designs. Five are RLM designs. EASY-TACH units are available with mogul or medium sockets through leading electrical distributors everywhere. For further details, contact the QUAD representative nearest you or mail coupon today!

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REFLECTORS ALL WHITE OR GREEN OUTSIDE

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32 South Peoria Street, Chicago 7, Illinois
Please send me details on QUAD EASY-TACH.
☐ Include catalog of complete line.
Name_____
Address_____
City_____ State_____

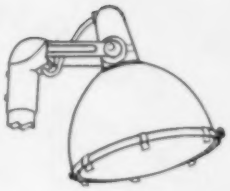
Revere Outdoor Lighting Report

Revere ELECTRIC MFG. CO.

Lighting an automobile sales lot

The Problem: To illuminate a long, deep sales area so that cars, signs, and buildings would attract attention and look more appealing to passers-by.

The Answer: Five poles, each mounting ten Revere No. 7403 *1000-watt* mercury floodlights on a No. 217-ZA bracket, were installed to provide the high level of lighting desired. Ten No. 3510-AL Revere Par Lamps are also mounted on each pole 10 feet above grade to highlight the color and beauty of the cars and create more sales appeal.

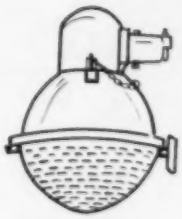


No. 7403 Floodlight

Lighting a city street

The Problem: To provide a lesser traveled secondary street with uniform, moderate-level lighting, in the most efficient, economical way possible.

The Answer: Revere Star-Lux incandescent street lighting luminaires were installed on converted concrete poles to provide efficient lighting at low cost. The Star-Lux uses up to 10,000 lumen incandescent lamps or 250 to 400-watt mercury lamps to provide any of the five standard A.S.A.-I.E.S. distribution patterns.

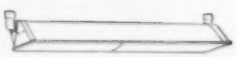


No. 2311-A/2363
Star-Lux Luminaire

Lighting a poster board

The Problem: To assure greater night visibility of an advertiser's poster board sales message by providing higher level, more uniform illumination.

The Answer: Revere Fluoresign outdoor luminaires with very high output fluorescent lamps were installed to give the high level of illumination desired. Reflector and lamp assembly may be positioned at any desired angle for uniform light distribution. Lamps give 10 times the rated life of incandescent types. Fixtures are unobtrusive, too.



Fluoresign Luminaire

Write for Revere's complete catalog of outdoor lighting equipment

Revere ELECTRIC MFG. CO.

OUTDOOR LIGHTING

Revere Electric Mfg. Co. • 7420 Lehigh Avenue • Chicago 48, Illinois (In suburban Niles)
Long Distance Phone: NIles 7-6060 • Chicago Phone: SPring 4-1200 • Telegrams: WUX Niles
In Canada: Curtis Lighting, Ltd., Leaside, Toronto, Ontario

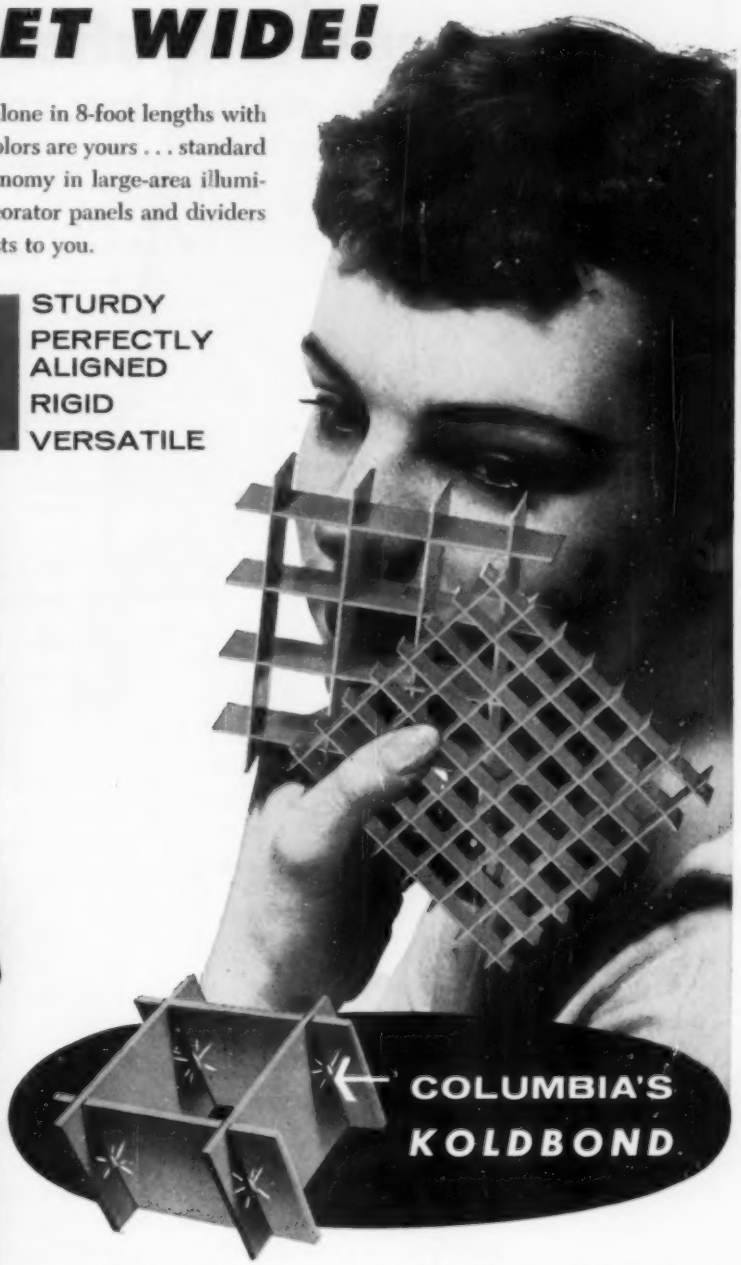
COLUMBIA'S COLORED KOLDBOND ALUMINUM LOUVERS

½″ x ½″ x ½″ and 1″ x 1″ x 1″ . . .

NOW 4 FEET WIDE!

Big, strong panels rigid enough to stand alone in 8-foot lengths with no bend or crack. All sorts of soft, pastel colors are yours . . . standard or to your specification. Designed for economy in large-area illuminated ceilings or modules, for interior decorator panels and dividers . . . or for whatever your creativity suggests to you.

STURDY
PERFECTLY ALIGNED
RIGID
VERSATILE



SEND FOR FREE SAMPLES OF COLORED KOLDBOND LOUVERS

The exclusive Koldbond process gives Columbia louvers their amazing strength and rigidity. There is no weld to sag or break. Koldbond is unduplicated and unequalled by anyone, anywhere . . . exclusively yours from

COLUMBIA ELECTRIC & MANUFACTURING CO.
N. 2310 FANCHER WAY • DEPT. I-1
SPOKANE 10, WASHINGTON

"97% of our General Electric Power Groove Lamps are still going strong after 6500 hours!"

SAYS ERICKSON TOOL COMPANY, SOLON, OHIO

ERICKSON TOOL COMPANY
34350 SOLON ROAD
SOLON, OHIO

December 22, 1958

Mr. Q. D. Dobras
Application Engineering
General Electric Lamp Division
Nela Park, Cleveland 12, Ohio

Dear Mr. Dobras:

Thanks for your continued interest in our Power Groove lighting system. You have more and more reason to be proud of it.

You told us these lamps had a useful life expectancy of 5,000 hours. Now, after 15 months, or a full 6,500 hours of use, only 3% have burned out! In my opinion this is an excellent record of performance.

As you can tell, we're still mighty pleased we selected Power Grooves for our lighting. They've helped us maintain our high-quality production standards (the men think they're great), and they're practically maintenance-free.

Sincerely,

S. S. Benjamin, Vice President
Erickson Tool Company

SSB/dmw

G-E POWER GROOVES give nearly twice as much light as high output fluorescents—2½ times as much as slimlines. You can offer your customers more light per fixture, with fewer parts to maintain, and savings of 5% to 20% on original investment.

FREE! NEW 24-PAGE BOOK entitled "21 Industrial Lighting Problems Solved With Power Grooves". Illustrated book gives you the whole story on G-E Power Groove Lamp design—plus specific details on how to give customers the highest, most economical lighting levels. For your copy, write: General Electric Co., Large Lamp Dept. C-901, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

YOU CANNOT MISS

In your aim to obtain better lighting for better vision you will get a bull's-eye every time that you specify or select Sunbeam Lighting. Your chances of direct hits are greatly enhanced by the following factors: 1. All Sunbeam Visionaires® are designed, engineered and test-proven to produce specific illumination results. 2. You can choose from the largest line of quality luminaires in the country for almost every commercial, institutional and industrial application. 3. Two complete manufacturing facilities are strategically located to provide rapid, nation-wide deliveries. Typical of the many modernly styled and easy to install fixtures are the SHALLORAMA®, SIGHTLINE® and CSP3800 Visionaires®

Specify SHALLORAMA® for new or remodeled interiors, especially in low ceiling areas. They look recessed. The Plexiglas diffuser is guaranteed for 15 years.

Select the "large-area" circular, recessed #CSP3800 Visionaires for architectural contrasts. Domed Plexiglas enclosed in smart trim.

Recommend SIGHTLINE® for the ultimate in comfortable, glare-free illumination. A totally indirect lighting system that blends with the ceiling. Ideal for critical seeing areas.

SUNBEAM Visionaires

Sunbeam Lighting Company, 777 East 14th Pl., Los Angeles 21, California

Gary, Indiana

Photo courtesy Wheeling Steel Corporation, Wheeling, West Virginia (Benwood Works)

Wheeling Steel specifies...

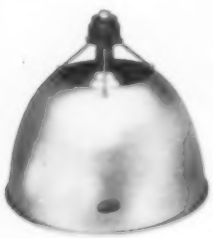
Abolite uplight fixtures for extra eye comfort, economical high bay lighting

These Abolite uplight fixtures are mounted forty feet high, yet there's comfortable, glareless 32 footcandle average light throughout this high bay building. Light directed upward through the fixture's open top eliminates sharp contrasts by washing out dark background shadows. Glare is virtually eliminated by 35° lamp shielding.

Abolite's modern air-swept design also reduces maintenance costs. Air circulating through the fixture sweeps it clean of dulling dust.

You can choose from several Abolite uplight units for high bay lighting: 18" and 24" diameter Alzak aluminum fixtures for use with 400 and 1000 watt mercury lamps and 14" and 18" diameter Alzak aluminum fixtures for 300-500 watt incandescent lamps (ideal for gymnasium lighting). For full information see Sweet's Industrial Construction File 12i/AB, or write *Abolite Lighting Division, The Jones Metal Products Company, West Lafayette, Ohio.*

INSTALLATION DATA:
Abolite Cat. No. HMFAU-2400 Alzak aluminum uplight fixtures with 400 watt white reflector mercury lamps. Mounting height 40' with 16' x 20' spacing. Average footcandle level: 32.



ABOLITE Lighting

THE JONES METAL PRODUCTS COMPANY
West Lafayette, Ohio

eye-fi RE/LIGHTING

ENCLOSED PLASTIC EXTRUDED SHAPES

for lighting fixture side panels

- Better diffusion
- More rigid assembly... Up to eight foot installations
- Perfect for use with K-LITE Prismatic Lens Panels

CALL YOUR nearby KSH executive-engineer for on-the-spot service.

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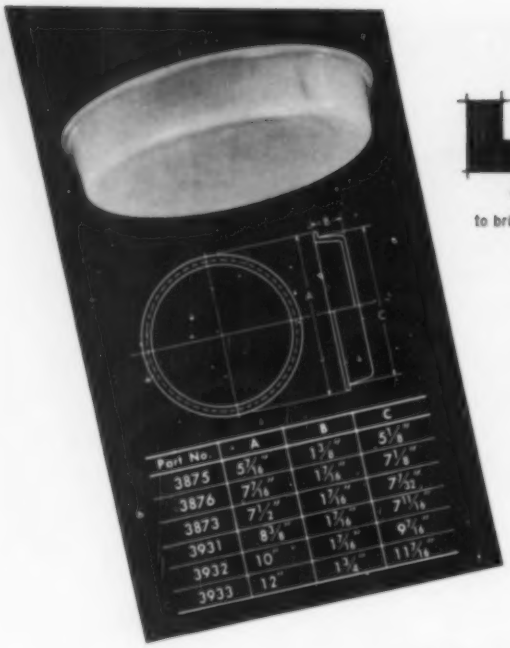

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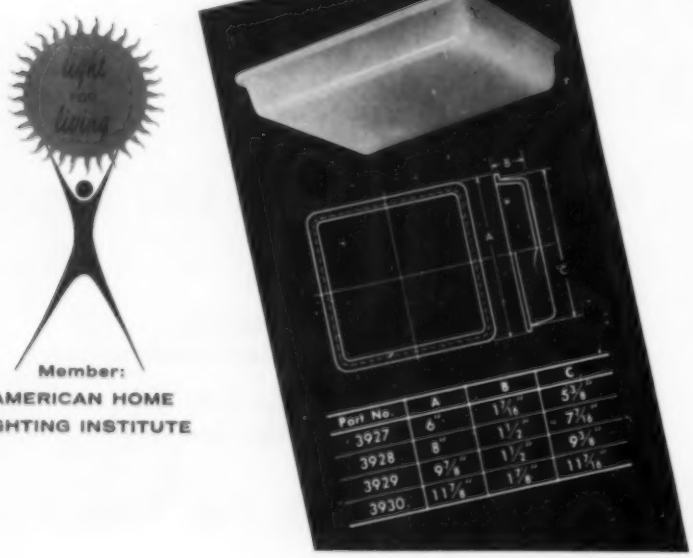
For applications requiring high intensity—low brightness!

As a member of the American Home Lighting Institute, Lancaster is actively engaged in the development of glass and plastic components that will advance home lighting standards—substantially improve the appearance, efficiency and sale of home lighting fixtures. Case in point: Lancaster Moonstone diffusers offer controlled distribution of light, less glare, greater eye comfort—are available in 2 popular shapes that harmonize perfectly with modern commercial and home interiors. Write or call OLive 3-0311 for prices and free Lighting Glassware Catalog. Lancaster Glass Corporation, Lancaster 1, Ohio. Sales Offices: New York City—CHelsea 3-5750; Los Angeles—CApitol 2-8128.



light and living

Member:
AMERICAN HOME
LIGHTING INSTITUTE

(*Continued from page 21A*)

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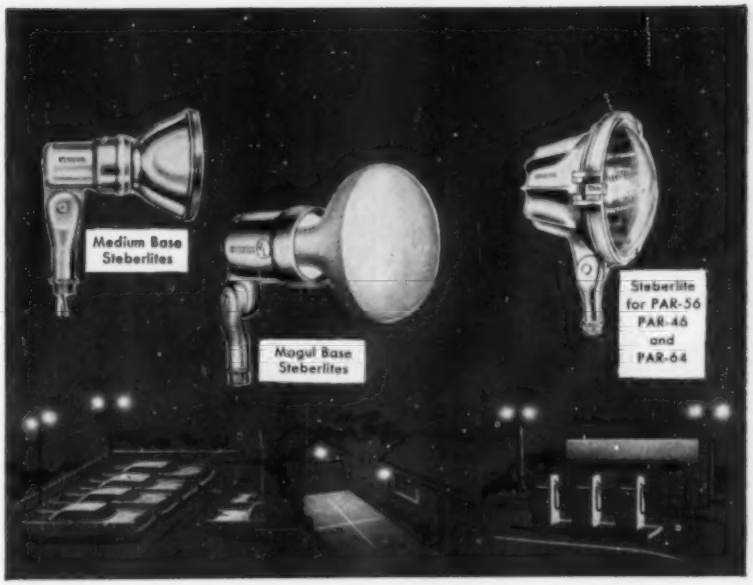

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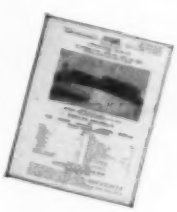

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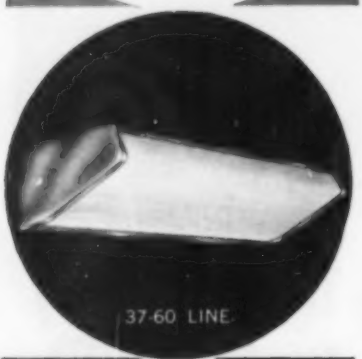
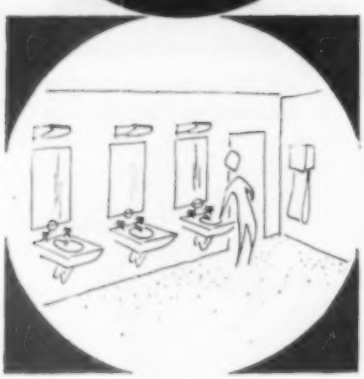
new

lighting design by mc Philben





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Available in both fluorescent and incandescent models offering these exclusive features: continuously hinged doors for easy relamping . . . all metal construction . . . baked on grey enamel finish . . . removable reflectors for easy access to electrical components.

37-60 Two 60 watt lamps
37-65 Two 15 watt T-8 fluorescent lamps

Contact your mcPhilben representative for full details. See our insert in Sweet's file 32a or write for data sheet C/27 mc

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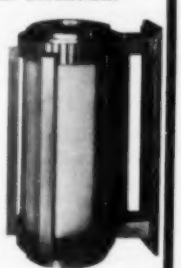
GENUINE BRONZE, ALUMINUM, WROUGHT IRON, STAINLESS STEEL

for Churches, Hospitals, Public Buildings, etc. No order too large, none too small for our personal attention.

Your inquiry is appreciated.



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January 1959

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The Brand New Idea in Light Reflecting Material!

- High specular reflectivity at lowest cost.
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- Ready to form and use, no buffing or anodizing.
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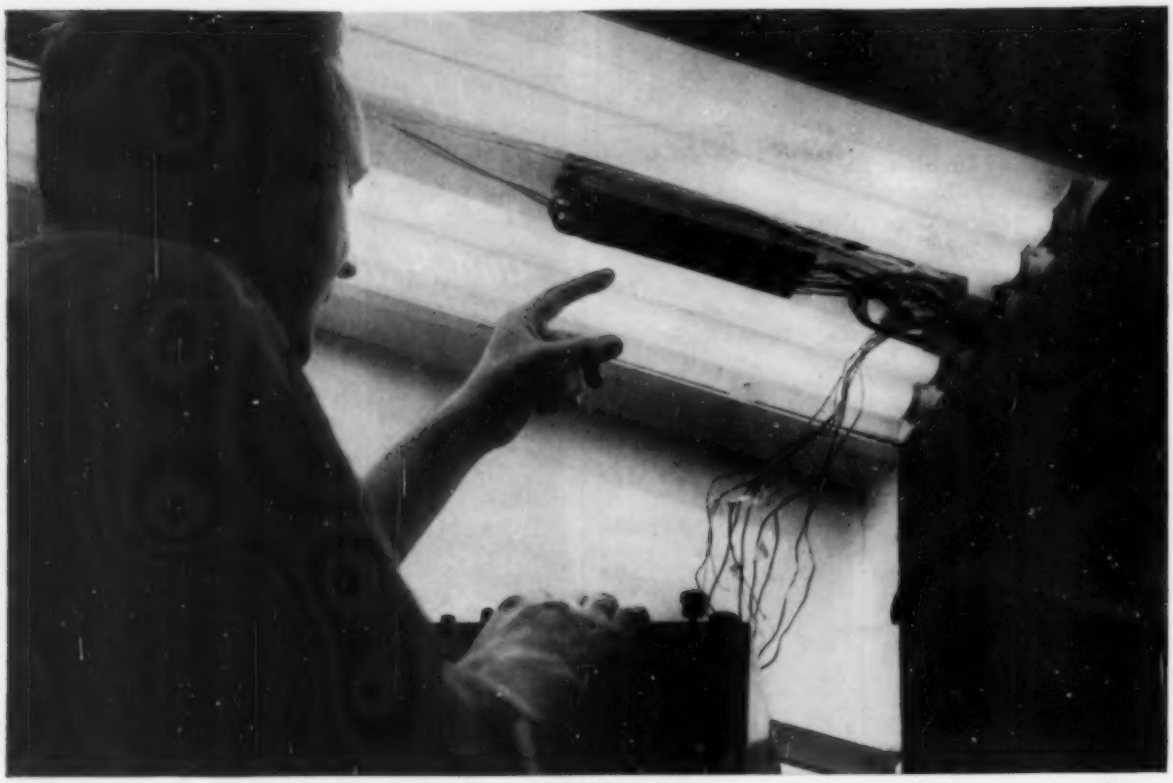


New rapid-start ballast for two 40w lamps proved under severe test conditions

New cool Sola rapid-start ballast easily passes "in-fixture" heat tests

Sola engineers the ballast to be an integral part of the fixture rather than as an isolated component. This new ballast was consequently designed to pass exacting "in-fixture" tests, for superior performance under the most demanding operating conditions.

This new two-lamp, 40-watt, rapid-start ballast is built to allow a coil-temperature rise of only 42°C when tested according to U.L. and E.T.L. methods.

In our own laboratory the new ballast was installed in a four-lamp fixture, completely enclosed and surface-mounted on acoustical material. Temperature in the fixture channel was 18°C hotter than the usual 40°C ambient of U.L. and E.T.L. tests. The following impressive results were recorded:

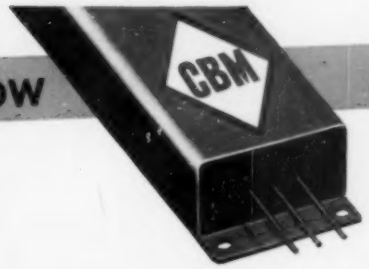
- Maximum coil temperature was 89.3°C—15°C cooler than the limit of Class A insulation.
- Temperature of the capacitor's case was within the heat limits of the capacitor's insulation.
- The "hot-spot" temperature on the ballast case was 81°C — 5°C cooler than premium-priced ballasts similarly tested, 9°C cooler than the maximum allowed under U.L. fixture requirements.

Our new level of coolness in ballast case, coils and capacitor contributes to full ballast life. This premium performance is offered at no price penalty.

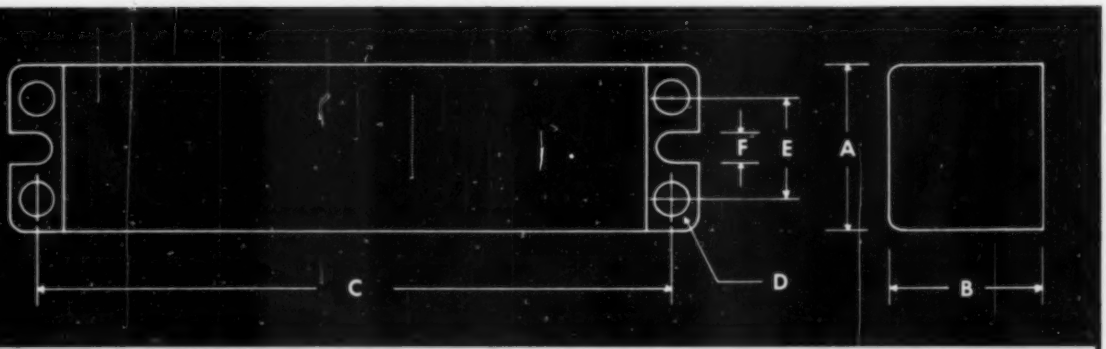
Sola will furnish fixture manufactures with samples of this new ballast (Catalog No. 670-109). Write to us on your business letterhead, and a Sola sales engineer will promptly supply your test ballasts. Sola welcomes the challenge of having you evaluate this cool new ballast in your own fixtures. If you wish merely to examine data on the new model, please request Bulletin FL-352. Write to the Manager, Lighting Sales.

Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill., Bishop 2-1414 • Offices in principal cities • In Canada, Sola Electric (Canada) Ltd., 24 Canmotor Ave., Toronto 18, Ont.

HOW CBM ASSURES YOU BETTER BALLAST VALUE



New recommended standards for ballast cross section and mounting dimensions aid fixture designers, architects, engineers, add flexibility for purchasing and replacement.



DIMENSIONS (INCHES)

	(MAXIMUM) CROSS SECTION		LENGTH (NOMINAL)										CORNER MTG. HOLES		CENTER (MAX.) MTG. SLOT
	A (WIDTH)	B (HEIGHT)	C (MOUNTING)										D (DIA.)	E (WIDTH)	F (WIDTH)
1	2-3/8	1-11/16	6	7-13/16	8-57/64	9-17/32	11-1/4			14-7/16	15-7/16		15/64 or 7/32	1-11/16	5/16*
2	2-13/16	2			8-57/64		11-1/8		13-3/4				15/64 or 7/32	2	5/16
3	3-1/8	1-25/32			8-57/64		11-9/64		13-3/4				15/64 or 7/32	2	5/16
4	3-3/16	2-3/8			8-57/64		11-9/64		13-3/4			18-5/8	15/64 or 7/32	2	5/16
5	3-3/16	2-5/8			8-57/64		11-9/64	13	13-3/4		15-5/8	16-1/8 18-5/8	15/64 or 7/32	2	5/16

**Drawn cases use center slot only for mounting.*

HERE'S an example of CBM at work to give the fluorescent lighting industry better ballast value. As the result of a study by one of the technical committees of the Certified Ballast Manufacturers Association . . .

22 different cross section dimensions for ballasts were cut to 5;

35 different mounting lengths were reduced to 14.

Obviously, this offers practical advantages to fixture manufacturers and engineers in the design of new units—and makes for a wider choice of component sources.

But this is over and above the basic contribution of CBM—the specification that assures quality performance from ballasts . . . including high light output, long lamp life, high power factor, long life service . . . with conformance checked and certified by Electrical Testing Laboratories. And of course, Certified CBM Ballasts are UL listed!

Learn why Certified CBM Ballasts serve you better . . . why it pays to specify fluorescent fixtures equipped with CBM Ballasts as their control center. Write for: *How to Insure Your Lighting Investment.*

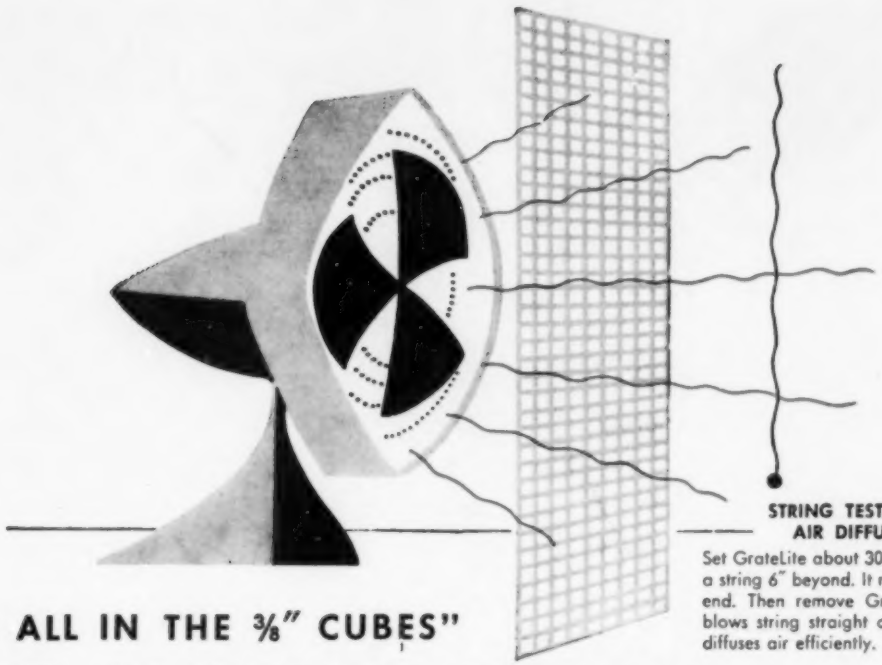
Chairman of CBM Technical Committee on study of ballast case dimensions discusses a point with a colleague . . . one of many sessions.

CBM CERTIFIED by ETL

CERTIFIED BALLAST MANUFACTURERS

2112 KEITH BUILDING
CLEVELAND 15, OHIO

Participation in CBM is open to any manufacturer who wishes to qualify



STRING TEST PROVES AIR DIFFUSION!

Set GrateLite about 30" from a fan. Hold a string 6" beyond. It ripples from end to end. Then remove GrateLite—and fan blows string straight outward! GrateLite diffuses air efficiently.

"IT'S ALL IN THE ⅜" CUBES"

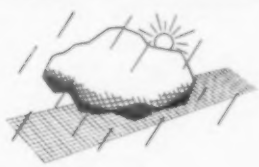
GUTH GRATELITE CEILINGS ARE GREAT!

LOUVER DIFFUSER*

SUPER-COMFORT LIGHTING PLUS AMAZING AIR DIFFUSION

AIR CONDITIONERS USE ITS PRINCIPLE!

Small GrateLite-type plastic cubicles are used on latest model air conditioners to diffuse air efficiently. GrateLite scatters—diffuses AIR!



UNAFFECTED BY HUMIDITY!

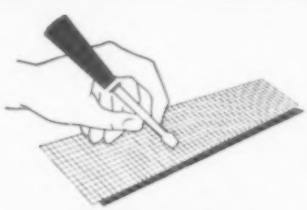
GrateLite is one solid piece—not just glued-together pieces! It is dimensionally stable, and is unaffected by changes in humidity or by high humidity itself. GrateLite is a solid body!

TOUGH AND RUGGED!

You can step on GrateLite . . . it won't mar, crumble or crunch. Its solid tapered vanes are Guth-engineered for maximum strength and ruggedness—important in maintenance!

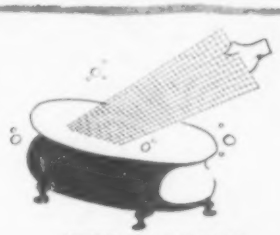
STANDS ROUGH HANDLING!

GrateLite won't bend, buckle or mar when taken down for cleaning and relamping, etc. It won't twist in your hand. Its body and substance are designed for long use.



SCRATCH-RESISTANT!

GrateLite doesn't scar easily—or rip or break when dropped or struck by a tool. Fingernails can't mar its usefulness. No "black eyes," no damaged cubicles to destroy overall beauty and efficiency.



KEEPS ITS BEAUTY!

GrateLite holds shape when washed. Won't oxidize or blacken. Cubicles retain their shape. Scratches are unnoticeable. GrateLite isn't flat, dull or depressing. It's always cheerful, life-like and radiant.

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THE EDWIN F. GUTH CO. Guth **ST. LOUIS 3, MO.**

TRUSTED NAME IN LIGHTING SINCE 1902

* U. S. Pat. No. 2,745,001. Can. Pat. 1957, No. 538,245